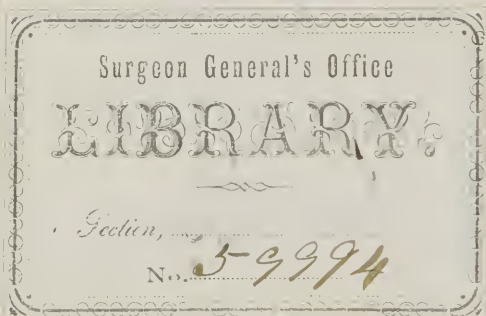
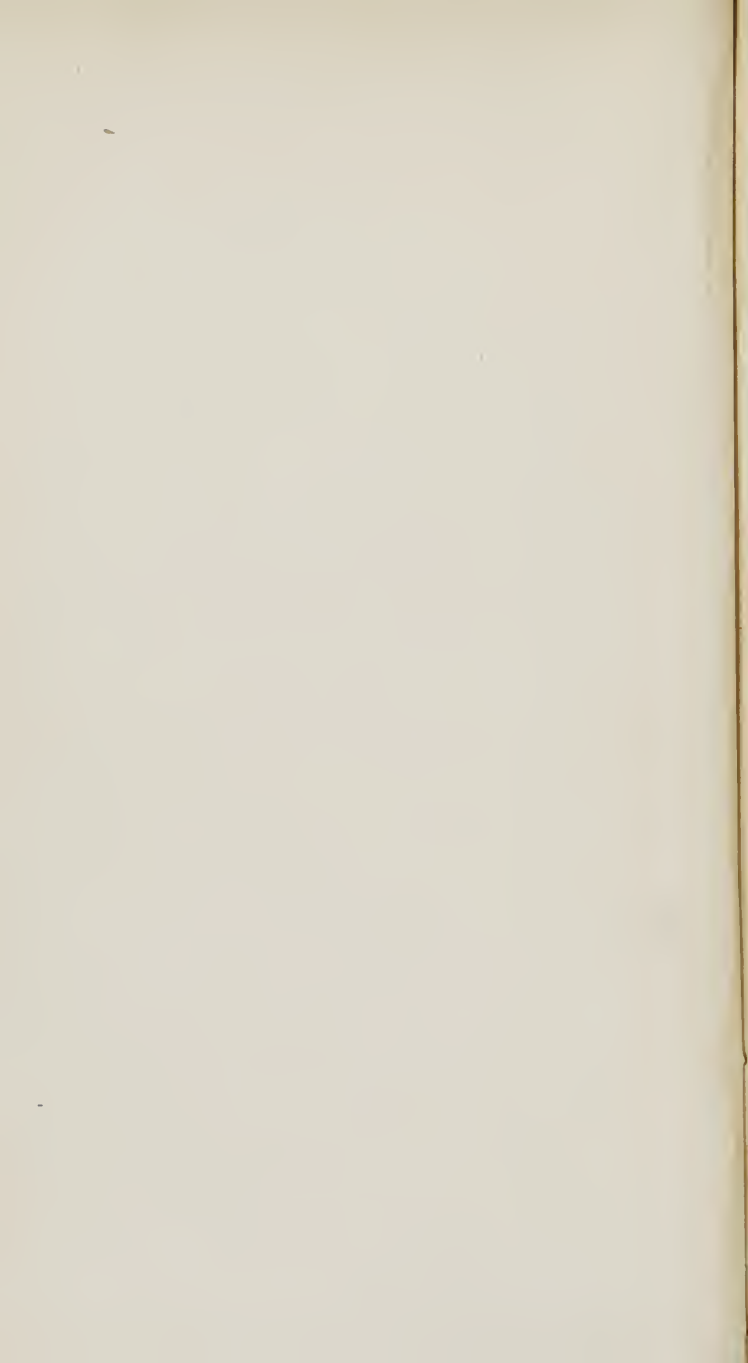


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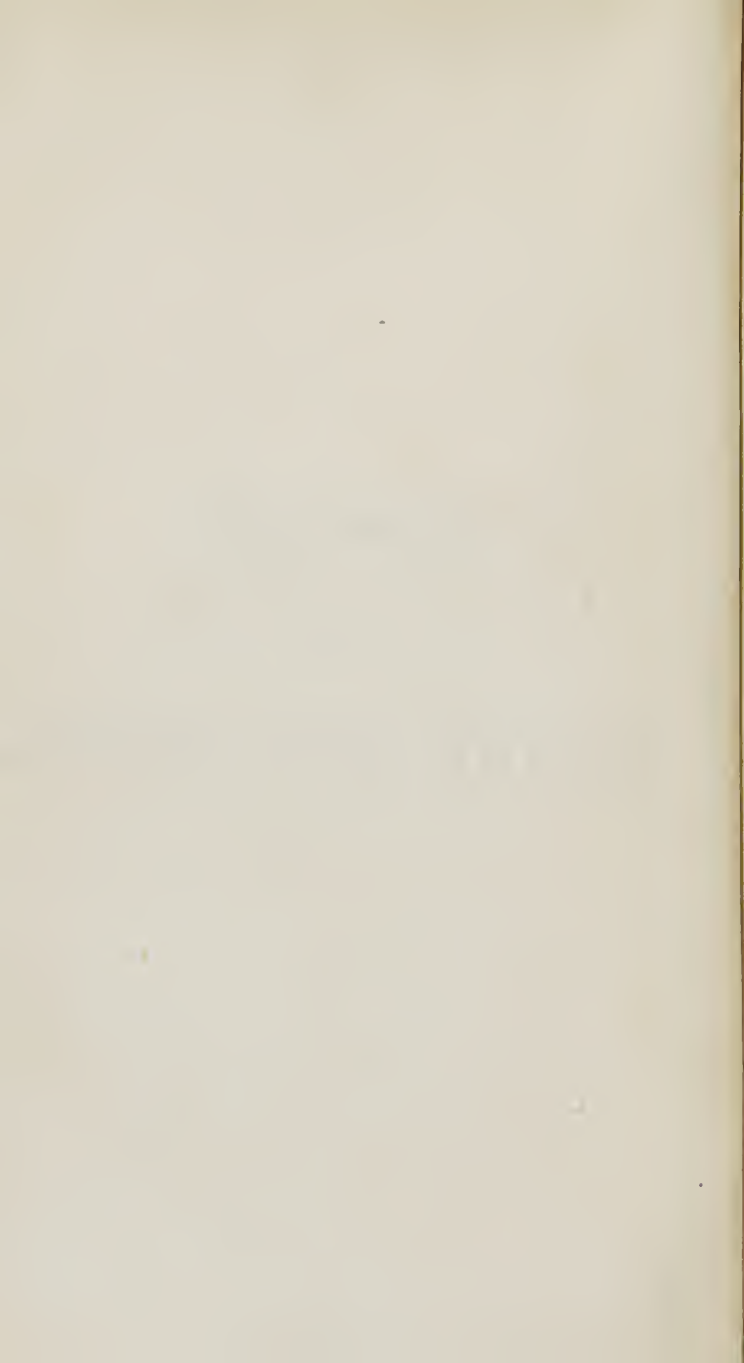




M A N U A L S

ON THE

B L O O D A N D U R I N E.



ON THE

# BLOOD AND URINE.

BY

JOHN WILLIAM GRIFFITH, M.D., F.L.S., &c.

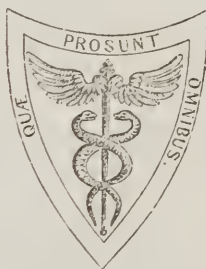
G. OWEN REES, M.D., F.R.S., F.G.S., &c.

AND

ALFRED MARKWICK, M.D., &c.

IN ONE VOLUME.

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PHILADELPHIA:  
LEA & BLANCHARD.

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1848.

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## ADVERTISEMENT.

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THE three works embraced in this volume, were published in London separately; but the immediate connection and importance of the subjects treated, have induced the AMERICAN PUBLISHERS to embody them in a volume suitable for reference and preservation.

*Philadelphia, March, 1848.*

A  
PRACTICAL MANUAL,  
CONTAINING A  
DESCRIPTION OF THE GENERAL, CHEMICAL  
AND MICROSCOPICAL  
CHARACTERS OF THE BLOOD,  
AND  
SECRECTIONS OF THE HUMAN BODY,  
AS WELL AS OF THEIR COMPONENTS,  
INCLUDING BOTH THEIR HEALTHY AND DISEASED  
STATES; WITH THE BEST METHODS OF  
SEPARATING AND ESTIMATING THEIR INGREDIENTS;  
ALSO,  
A SUCCINCT ACCOUNT OF THE VARIOUS CONCRETIONS OCCASIONALLY  
FOUND IN THE BODY AND FORMING CALCULI.

BY  
JOHN WILLIAM GRIFFITH, M.D., F.L.S., &c.

5-9994  
PHILADELPHIA:  
LEA & BLANCHARD.

1848.

TO  
GOLDING BIRD, A.M., M.D., F.L.S.,

ASSISTANT PHYSICIAN TO GUY'S HOSPITAL,

&c. &c.,

AS A SLIGHT TESTIMONY OF RESPECT

AND GRATITUDE

FROM HIS OBLIGED AND SINCERE FRIEND,

THE AUTHOR.

## P R E F A C E .

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THIS Manual is intended to assist the practitioner or student in medicine in discovering the deviations from health, and their nature in the blood and the various secretions of the body. An outline of the mode of analysing the different products, sufficient for practical purposes, is also subjoined, so as to make it a complete practical manual. The several branches of this subject have lately received a large share of attention, particularly from the German and French authors : and treatises somewhat analogous to this have appeared in those languages. The absence of such a one in this country has induced me to undertake the filling up of this deficiency. Much has also lately been done in the application of organic chemistry to the explanation of the phenomena of healthy and morbid actions. But I have avoided any notice of these views, as in many cases they are quite theoretical, and in the majority not well established. The use of the modern microscope is revealing to us the true structure of bodies in health, and their alterations in disease, with their true relations to their vital products, secretions. And as recourse to the microscope often abbreviates chemical experiments, and enables us to ascertain the chemical nature of very minute portions of matter, I have added an account, with figures of the microscopical characters of each substance. In some cases, where I have not had opportunities, or at least insufficient ones, of testing their accuracy, or where I do not feel authorised in assenting to the correctness of their observations, I have borrowed the statements of former authors,

and have given their names as authorities. Further information on these subjects and all their branches may be obtained from the writings of Becquerel, Berzelius, Bird, Christison, Liebig, Prout, Rayer, Rees, Simon, Turner, Vigla, Vogel, and Willis, to whom in some instances I am much indebted. I have also to acknowledge the kind assistance offered me on several occasions by W. Francis, Esq. It is to be wished that the facility I trust this Manual will afford those anxious to prosecute this most interesting branch of medical inquiry, in examining and appreciating morbid states of the various secretions, may enable us shortly to arrive at some more satisfactory conclusions respecting the pathological relations of these fluids.

9 St. John's Square,  
April, 1843.



# PART I.

CONTAINING THE

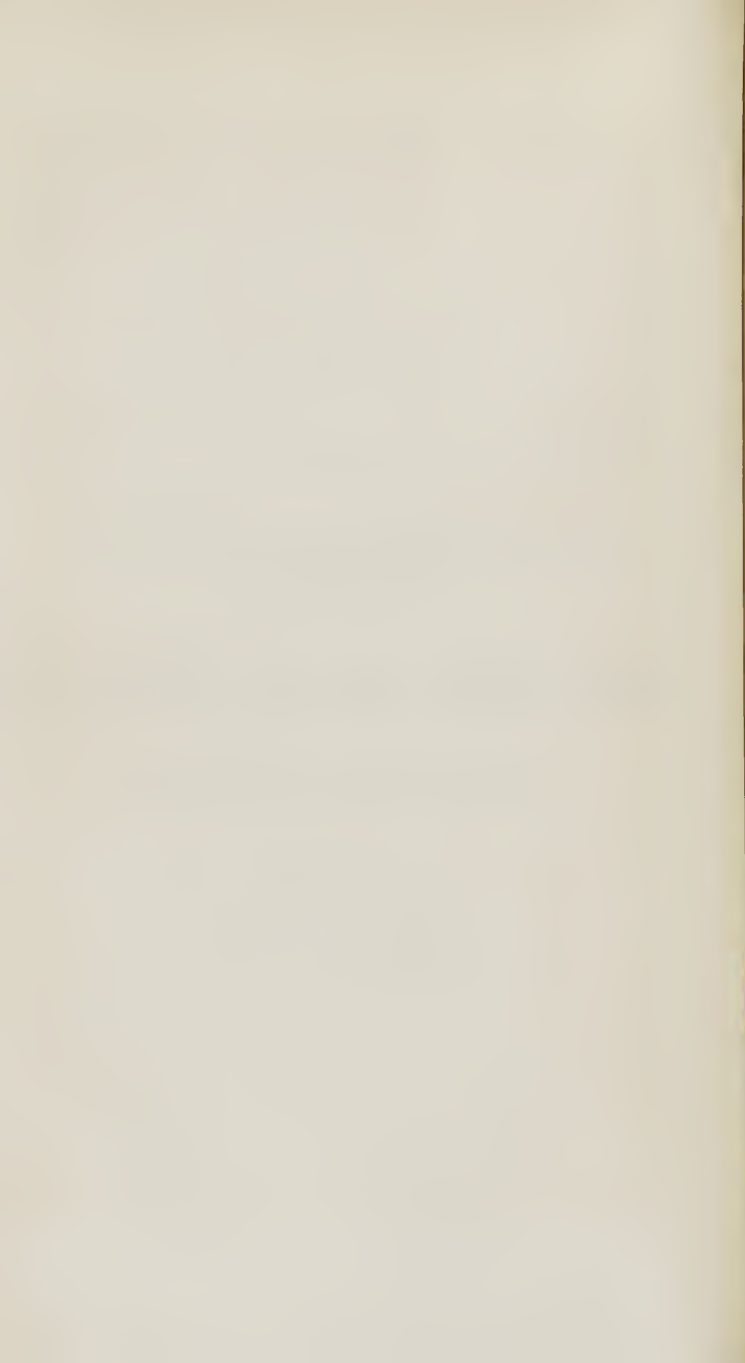
GENERAL, CHEMICAL, AND MICROSCOPICAL  
CHARACTERS OF

THE URINE AND ITS DEPOSITS,

BOTH IN HEALTH AND DISEASE,

AS ALSO THOSE OF

VESICAL CALCULI.



## INTRODUCTION.

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To those unaccustomed to chemico-microscopical examinations the following observations will save much trouble and vexation.

I. The specific gravity of urine is taken either by the Urinometer or the Specific Gravity bottle; if the former be used we should bear in mind that its indications are never so correct as those of the bottle, although quite sufficiently so for ordinary purposes; and moreover, those instruments sold at the shops should always be carefully tested as regards accuracy, by comparison with some standard instrument or the bottle.

II. In testing the acidity of urine use *thin* blue, and for alkalinity slightly reddened litmus paper. I have repeatedly seen urine considered neutral from neglect of attention to the former circumstance when it was decidedly acid.

III. Be sure your tests are pure, otherwise in operating on small quantities, you will be extremely puzzled at some of your results. The purity of your tests will be sufficient, provided they stand the examination required by the London Pharmacopœia. Oxalate of ammonia, not mentioned there, should be entirely dissipated by heat; and all that is precipitated from its solution by chloride of barium should dissolve in nitric acid.

IV. The best mode of microscopically examining urinary sediments is this:—Allow the urine to stand; decant the supernatant fluid; pour the remainder into a watch-glass; draw off the small quantity of fluid remaining after a short repose by means of a pipette, and then it can be conveniently viewed under the field of the microscope. In most cases an achro-

matic half-inch object-glass will be quite sufficient for the discernment and distinction of these deposits ; but some few require one-eighth of an inch, as the pus and mucus globules, lithate of ammonia, and oxalate of lime. In urine, as is very frequently the case, where there is much lithate of ammonia mixed with the sediment, warm it gently in a watch-glass, then the supernatant liquid containing the lithate in solution can be removed by the pipette, and any insoluble sediment distinctly perceived. When we use the high powers of the microscope, we must not view sediments in a watch-glass, but, having obtained them moist in the watch-glass as above, pour this on to the middle of a glass slip, then drop a small square of thin glass over it ; thus we have the object perfectly flat, the moisture is prevented from condensing on the object-glass, and there is no risk of scratching the latter.

V. It is often required for the sake of comparison to preserve these sediments : this may be done either moist or dry. Those only are preserved moist which are very transparent, as the oxalate of lime, globular lithate, pus, blood, &c. ; the rest may be preserved in Canada balsam. Whenever you intend to preserve any deposit, be sure first to wash it well with distilled water, to free it from the gummy deliquescent matter with which it is combined in the urine. If to be preserved in balsam, allow it to dry on a glass slide ; then hold some Canada balsam on the end of a stick over a spirit-lamp at some distance from the flame,\* so that it shall gently melt ; just as it has melted and is on the point of dropping from the stick, hold under it the previously gently warmed glass slip lying on which is the deposit ; in this manner so much of the balsam may be dropped on the glass as is sufficient to cover the deposit : while it is still warm, drop on the surface of the balsam a slip of thin glass, also previously warmed, press this gently, allow the whole to become hard, and the specimen is permanently pre-

\* If this be not attended to bubbles will be formed and the specimen spoiled.

served. All the objects for examination by polarized light are beautifully prepared in this manner. Those to be kept moist, are washed carefully, placed on a glass slip, and a drop or two of weak spirit, water saturated with creasote, or Godby's fluid,\* used without heat in the same manner as the balsam. As soon as all the fluid not confined between the two glasses has been carefully wiped away, surround the thin glass at its edges with gold size thickened with lamp-black (this may be dropped around the edges of the glass with the end of a pen,) and allow it to dry; thus we have the specimen permanently preserved in a cell. Some objects require to be preserved in syrup; a strong syrup should be made mixed with a little gum, this should be kept for some time, and then used without heat in the same way as the balsam. Salts and pus, with other organic globules occasionally present, may be well preserved in this way.

VI. I shall now give an abstract account of the ordinary modes of procedure in the analytical examination of the urine, the minute details will be found in other parts of this work. When we wish to examine any specimen of urine, it is very important that some of its characters should be ascertained as soon as possible after it has passed; this is particularly the case with those specimens which contain excess of urea or mucus, as alkalinity occurs so soon in some of these cases, in the secretion which is acid at the time it is passed, as to be without care a source of error. Those containing excess of acid keep better. The first point then is to note its acidity (II.) The amount may be estimated by neutralizing the free acid by a dilute solution of ammonia, the quantity of the solution required, and whose strength is previously known, will indicate the proportion of acid. We now set it aside and allow the sedimentary portions to subside. Then having noticed the apparent characters of the sediment, pour off the upper clear

\* This is composed of bay-salt, one ounce; alum, half an ounce; corrosive sublimate, one grain; distilled water, half a pint.

portions (should the upper part not be clear it can be filtered.) We next notice the colour of the urine, and also take its specific gravity.  $\alpha$ . The sedimentary portion must be examined microscopically (*vide* IV.) and then chemically. We have now obtained some idea of its constituents; the peculiar appearances of the organized portions can be compared with the figures in the Plates (Pl. I. and II.) and if there be any doubt about their composition, they can be examined chemically.  $\beta$ . Should the sp. gr. of the urine be above or about 1030, we may *suspect* the presence of either sugar or excess of urea. The former may be ascertained by setting aside a portion in a warm place; the production of the peculiar vegetable organizations, forming the white powdery surface, will readily decide this question (33.) The excess of urea may be also readily detected (11.) Should its sp. gr. be low, if the colour is pale and the urine clear, most probably the quantity is increased, and the solid contents diminished; if it be not clear but muddy and dull, albumen may be suspected, the presence of which is readily detected by ascertaining that the urine is acid and then boiling (19.) In all cases where we are about to analyse the urine quantitatively, a small portion should be examined previously, so that we may become acquainted with the predominating ingredients. Should the urine contain much mucus, this may be thrown down by acetic acid or alcohol; by its being thus coagulated the fluid portion passes readily through the filter. In ordinary cases of filtration, where the fluid is not loaded with insoluble portions, we may use filters whose weight is previously known, and the residue after combustion is very minute, and also previously known.

Supposing then we have disposed of the deposits, and the filtered liquor is clear, if it contain albumen this is first estimated by boiling a proper quantity. The albumen thus coagulated is collected on a filter, washed (the washings must be added to the filtered liquor,) and dried in a water bath. The weight of the dried albumen, *minus* the weight of the filter, gives us the absolute quantity of the former which the boiled

portion of the urine contained. When we require to be very accurate, or operate on very small quantities, the albumen must be boiled in alcohol or æther previous to desiccation, so as to separate fatty matter. The filtered albuminous liquor, as well as the washings, or when no albumen is present, the original liquid is evaporated to dryness on the water-bath; the weight of the residue + the weight of the albumen when present is the amount of solid constituents. Should this residue contain any fatty matter, this can be separated by boiling æther; the weight of this æthereal extract + that obtained from the albumen gives us the whole amount of fatty matter. Sometimes the æther dissolves, besides fat, other matters, as salts, &c.; these are separated by washing with water. The extract which has been treated with æther is then acted upon by alcohol, sp. gr.  $\cdot 830$ ; this dissolves the urea, colouring matter, sugar (when present,) alcoholic extract, metallic chlorides (sodium, potassium,) and sal-ammoniac, with the lactates. The filtered solution, together with the alcohol used for washing, is then evaporated to dryness. The weight of the residue gives the weight of all the above-named compounds.  $\alpha$ . The urea is estimated by adding nitric or oxalic acid to its concentrated solution.  $\beta$ . If sugar be present, this is either allowed to crystallize, or its quantity is estimated by fermentation. (33.)

$\gamma$ . The fixed salts are estimated in quantity by incinerating the extract; the ash contains chloride of sodium, chloride of potassium as such, and the lactic salts with fixed bases as carbonates (14.) The sal-ammoniac and volatile lactates have disappeared. The separation of those organic matters soluble in alcohol from those insoluble in that liquid is not ordinarily necessary, the mode recommended in (14.) is sufficiently accurate.

Another mode is, using a separate portion to calculate the urea (this portion ought to be more considerable than the one we are about to mention; the latter may be very small, provided we have a delicate balance.) Evaporate, weigh, digest with alcohol, ( $\cdot 830$ ), and filter; lithic acid and the phosphates remain as a residue (these can be readily separated by the

solubility of the former in liquor potassæ.) The alcoholic solution is evaporated, dissolved in a considerable quantity of water, and boiled with caustic lime, until the urea is completely decomposed. The lime is precipitated by oxalic acid; the extract contains lactic acid, lactates, muriate of ammonia, and alcoholic extract, whose amount can be estimated by the filtration and evaporation of the liquid.

VII. The evaporations in all these cases should be performed in a steam-bath, or in some cases a water-bath may be used, but a high temperature should be carefully avoided.

VIII. All incinerations should be performed in a porcelain or platinum capsule; and whenever any liquid is to be filtered, the filter must be previously moistened with distilled water.

IX. All reactions in which colour is produced are best observed in white, earthenware, glazed, evaporating dishes or capsules.

X. A freezing mixture is readily made either by mixing powdered nitrate of ammonia and water in equal weights; or equal parts of nitre and sal-ammoniac powdered and added to four parts of water; or pounded ice and common salt.

Having now given what will be sufficient on the general methods of examination, I will proceed to minuter details.



GENERAL, CHEMICAL,  
AND  
MICROSCOPICAL CHARACTERS  
OF THE URINE, &c.

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1. THE function of the kidneys is to separate from the blood by their selecting power certain compounds which are of no further use in the animal economy, and the retention of which in the blood acts as a virulent poison to the system. These compounds dissolved in water and forming the urine are very numerous, and of very different natures; some undoubtedly exist in the blood, whilst the detection of others eludes our strictest chemical investigations, consequently we must believe that they do not exist in that fluid.

2. The quantity of urine passed daily varies greatly according to circumstances. In health the most important of these is the state of the skin; the state of the liver is also intimately associated with that of the kidney, and consequently of the urine. The normal quantity may be considered as between 30 and 40 ounces. The amount will be diminished if the secretion of the skin be much increased by active exercise, warmth, or sweating from any cause; and much increased if the functions of the skin be impeded or suspended; in cold atmospheres, after copious draughts of fluid, &c.

3. The odour when first passed is somewhat aromatic, but this disappears on cooling, when it is replaced by one peculiar to that fluid.

4. Urine is always acid in health; this acidity most probably depends upon the presence of acid salts. It does not, as was supposed, contain any super-salts of lime.\*

5. Its specific gravity varies greatly in health, and is in an inverse ratio to its quantity. It may be said to vary from 1015 to 1025; the average throughout the day would be rather less than 1020. If the specific gravity be higher, an increased amount of solids need not be necessarily inferred,† because the quantity of the fluid may be diminished; nor if the sp. gr. be much diminished, is a diminution of solids passed a necessary consequence, because the amount of the fluid may be increased; so that in estimating the value of the sp. gr. we must pay particular attention to the quantity. Three varieties of urine may be distinguished,—1st, that passed after drink, and which is exceedingly low in sp. gr., *Urina Potūs*; 2d, that which occurs after the completion of digestion, *Urina Chyli*, this is usually of the highest sp. gr. of any; 3d, that which is passed in the morning, and is secreted from the blood, consequently not immediately affected by ingesta; this is the *Urina Sanguinis*. This may be considered as the pure renal secretion, and is that which should generally be examined as indicating the state of the system.

6. The quantity of solid materials passed during the 24 hours varies according to the sp. gr.; it is on an average, in health,  $2\frac{1}{2}$  oz.:‡ the amount in any specimen of urine whose sp. gr. is known may be found out by reference to the following table:§—

\* Thomson, Animal Chemistry, 1843.

† I allude to the quantity per diem, not the absolute quantity under examination.

‡ Christison.

§ Becquerel.

Sp. gr. at 50° F.	Solids.*	Sp. gr. at 50° F.	Solids.
1001	1·65	1016	26·40
1002	3·30	1017	28·05
1003	4·95	1018	29·70
1004	6·60	1019	31·35
1005	8·25	1020	33·00
1006	9·90	1021	34·65
1007	11·53	1022	36·30
1008	13·20	1023	37·95
1009	14·85	1024	39·60
1010	16·50	1025	41·25
1011	18·15	1026	42·90
1012	19·80	1027	44·55
1013	21·45	1028	46·20
1014	23·10	1029	47·85
1015	24·75	1030	49·50

7. Urine is generally of an amber tint. The colouring matter varies much in its intensity, but it cannot be separated in a state of purity. The brown organic matter which gives the colour to inspissated urine and seems to be the source of its peculiar odour, has recently been examined, and has yielded a brown, fusible, resinous mass, having a strong odour of castoreum when dry, and a urinous smell when boiled with water.† The colouring matter is usually much increased in quantity when excess of lithic acid is present. Dr. Prout considers that there are two colouring principles in urine which are intimately related to each other, and which by their properties seem to indicate that they are related to lithic acid on the one hand, and some modification of that of the bile on the other. The colouring matter of the bile resembles lithic acid in assuming a purple tint by nitric acid. Polarized light when transmitted through healthy urine does not, when analyzed, develop any colour, nor is any notable change produced.

8. When healthy urine is first passed it is not quite transparent, but by repose it becomes so, and a very delicate cloud falls to the bottom of the containing vessel; this is mucus mixed with a few epithelial scales. Some have denied that there is any deposit in healthy urine, but by careful examination this is found invariably present. It may be

\* In 1000 parts.

† Scharling.

collected by filtering the urine, when it remains on the filter as a transparent colourless mass, of a shining appearance when dry.

*Chem. prop.*—It is readily soluble in nitric and acetic acids\* and in liquor potassæ; the acid solutions are precipitated by solution of ferrocyanide of potassium. It is not coagulated by boiling. It is insoluble in sulphuric acid. It contains albumen in some unknown state of combination, as it is not coagulated by boiling or nitric acid, although it is precipitated by galvanic electricity and ferrocyanide of potassium.

Mucus often exists in great excess in urine. In mild cases the ordinary mucous cloud is merely increased in quantity and retains the same appearance, except that upon careful examination we find very delicate opaque threads floating in it; these are composed almost entirely of the peculiar globules. When however it is more abundant it becomes much firmer, and often forms large gelatinous stringy masses, which can be drawn out in ropes. When present it soon causes the urine to putrefy. It does not render it coagulable by heat, although often so by acetic acid; moreover it does not give evidence of free albumen. The presence of mucus in the urine acts as a ferment, for after its separation it may be preserved a much longer time without decomposition.

*Microscop. characters.*—It is almost entirely composed of amorphous, extremely minute granular particles; sometimes we have one or two mucous globules similar to those of pus, and here and there an epithelial scale or two, but it is nearly all amorphous.

9. There is another deposit which often exists in urine and is quite consistent with health: this is the lithate of ammonia. When healthy urine is placed under the receiver of an air-pump with sulphuric acid, and the atmospheric pressure is removed, a copious amorphous precipitate of this substance occurs; also when the quantity of urine is much diminished and the temperature reduced, this compound falls. It may be readily known from all others by its solu-

\* When the secretion of mucus is much increased it is only partially soluble in acetic acid.

bility by boiling in water or urine, and its entire dissipation at a red heat; but for its minute characters *vide* (15.)

I. Having thus noticed the general properties of the healthy secretion and its deposits, we will now examine its chemical constituents in health, with the means of separating and estimating them.\*

10. The quantitative analysis of the urine which have been made are comparatively few, and that of Berzelius, which was made many years ago and has appeared in every work relating to the subject since, is almost the only published one which has been minutely carried out. But for practical purposes they are not required to be carried to the extent adopted by that illustrious chemist. The following may be taken as a type of what is quite sufficient for ordinary practical purposes:—

1. Water	.	.	.	972.	} = 1000 grs.
2. Urea	.	.	.	12.	
3. Lithic acid	.	.	.	0.398	
4. Fixed salts	.	.	.	6.918	
5. Ammoniacal salts and organic matters.				8.6†	

The fixed salts are chloride of sodium, sulphates of soda and potash, phosphate of soda, magnesia and lime: thus—

Chlorine	.	.	.	.	.	0.502
Sulphuric acid	.	.	.	.	.	0.855
Phosphoric acid	.	.	.	.	.	0.317
Soda	.	.	.	.	.	} 5.244
Lime	.	.	.	.	.	
Magnesia	.	.	.	.	.	
Potash	.	.	.	.	.	
						<hr/> 6.918

The organic matters and ammoniacal salts are lactic acid, lactate of ammonia, osmazone, animal extractive soluble in water only, muriate and phosphate of ammonia.

\* An excess of these constituting disease is noticed under each head.

† Becquerel.

11. UREA.—This ingredient enters most largely into the composition of the urine, and to it many of its most important properties are due. It is supposed to be generated in the human body during the destructive assimilation of the gelatinous tissues. It is formed in the blood, and the presence of the kidney is not necessary to its formation.

*Chem. prop.*—When pure it is perfectly colourless; neither acid nor alkaline; crystallizes in the form of very delicate and silky four-sided prisms. It combines with, but does not neutralize acids. It is soluble in its own weight of cold water and in every proportion of hot; in  $4\frac{1}{2}$  parts of cold and 2 of boiling alcohol, and it separates from the hot alcoholic solution on cooling. It is almost insoluble in sulphuric æther, forms crystalline compounds with nitric and oxalic acids, and is entirely dissipated by heat. It is composed of  $C^2 O^2 H^4 N^2$ . It is one of the few organic compounds which can be artificially prepared, and can be obtained thus:—Mix 28 parts of dry ferrocyanide of potassium with 14 of peroxide of manganese in powder, and make the mixture as intimate as possible. Heat this on an iron plate over a charcoal fire to a dull red heat; it must be well stirred while cooling. When cold digest it repeatedly in cold water, and mix the solution with  $20\frac{1}{2}$  parts of sulphate of ammonia. The first concentrated liquid obtained by washing the residuum should be set aside, and the sulphate of ammonia dissolved in the succeeding weak liquids. A copious precipitate of sulphate of potash falls. The supernatant liquor is decanted off and evaporated over the water-bath. More sulphate of potash falls, which is separated, and this is repeated as long as the sulphate continues to form. The liquid is now evaporated to dryness, and the solid residue is digested in boiling alcohol of 80 or 90 per cent. The urea is dissolved. It crystallizes as the solution cools or is evaporated.†

A concentrated aqueous solution of urea is not precipi-

\* Although the description of such details as those necessary for the preparation of urea may appear contrary to what is expected in a practical manual, the artificial production of this compound is so highly interesting, and the process so readily conducted, that I am sure it will not be out of place here.

† Liebig and Wöhler.



tated by nitrate of silver, bichloride of mercury, alcohol, infusion of galls, nor alkalies.

By the aid of the microscope we may ascertain the presence of a very minute proportion of urea. Evaporate its aqueous or alcoholic solution; then add a little nitric or oxalic acid; delicate silky crystals of nitrate of oxalate of urea occur. This evaporation should be performed on a glass slide, and the subsequent crystallization examined by the microscope.

The state of combination in which urea exists in the urine is not satisfactorily ascertained. MM. Cap and Henry stated that it existed combined with lactic acid; but others, on repeating their experiments, instead of obtaining lactate of urea, have obtained the urea pure, which most probably Cap and Henry have mistaken for the lactate.\* Moreover, M. Pelouze has proved that no such compound as lactate of urea exists.

Its strong aqueous solution is not decomposed by ebullition, whilst the diluted solution decomposes very rapidly, and is converted into carbonate of ammonia.† As it is so very soluble and readily decomposed, we generally estimate it in combination with nitric or oxalic acid. Its impure crystals can be best decolourized by a little permanganate of potash,‡ which destroys the colouring matter and has little action upon urea; an excess of the salt is removed by alcohol, which converts it into peroxide of manganese. It often exists in excess, sometimes with increase in the quantity of the urine, when that fluid is pale; it is always in excess when the quantity of urine is diminished and its sp. gr. high, and in combination with excess of lithic acid and the lithates.

a. When an equal volume of nitric acid is added to a portion of urine in a watch-glass, if there be no excess of urea present no crystallization takes place; but if there be

\* Turner's Chemistry by Liebig and Gregory; and Chemical Gazette, No. 3, December, 1842.

† M. Vogel found that the relative proportion of urea was not diminished in urine by keeping for six weeks, nor by boiling for three hours and a half, but this is certainly not commonly the case.—*Anleitung zum Gebrauch des Mikroskopes*, Leipzig, 1841.

‡ Turner's Chemistry by Liebig and Gregory.

excess, a brownish-yellow crystalline\* compound is formed; this is the nitrate of urea. Its appearance is preceded by the formation of some bubbles, and in acid urine these bubbles are generally more numerous the larger the quantity of urea present, so that its presence in excess may generally be foretold. Its crystallization sometimes takes place in a few minutes, sometimes it requires a lapse of several hours. This is a very rough method of detecting an excess of urea, and in making use of it we must carefully notice the temperature, because the higher this is, the less likely will the crystallization be to take place, and *vice versâ*.

b. To estimate its quantity more accurately proceed thus:

I. Evaporate the urine to dryness over a steam-bath; moisten this extract with water, and pour strong alcohol on it. Evaporate this to dryness with a very low heat; dissolve it in a small quantity of water, and add nitric acid; then place the compound in ice or a freezing mixture. Throw it then on a filter, and wash it with ice-cold water, gently press and dry it. By then subtracting the previously known weight of the filter from that of the dried filter containing the nitrate of urea, we ascertain the amount of the latter, and on subtracting the proportional of nitric acid from this, we obtain the weight of the urea present.

Nitrate of urea is composed of 52.63 nitric acid + 47.37 urea in 100 parts.

II. Evaporate a given weight of urine over the open steam-bath to dryness; boil successive portions of alcohol on the dry residue until nothing more is taken up; mix the liquors; evaporate to the consistence of an extract; redissolve in a small quantity of lukewarm water; add oxalic acid to this solution until no more becomes dissolved on heating the liquid to 122° F. Allow the liquor to cool; a crystalline deposit of oxalate of urea occurs; collect this on a filter, and wash it with a small quantity of weak solution of oxalic acid. This last, as well as the mother-liquor, must be evaporated to procure any crystals which may exist in them; the crystals must then be dried in bibulous paper; then redissolve them in water, and neutralize the oxalic

\* These crystals appear when perfect as rhomboidal tables, sometimes having the angles truncated. (*Vide* Pl. II. figs. 37 and 38.)



acid with carbonate of lime; filter and well wash the precipitate. Evaporate the filtered liquors and the washings over the open steam-bath, and weigh the extract.\* This should be entirely soluble in anhydrous alcohol; if not, the weight of the residue must be deducted from that of the extract; we thus get the weight of the urea. Or we may calculate the amount of urea by deducing its weight from that of the undecomposed oxalate, which is in general the best mode.

Oxalate of urea is composed of oxalic acid,	37·436
“ “ “ “ urea “	62·564
	<hr/>
	100·00†

III. Or nitric acid may be used instead of the oxalic, and the nitrate of urea decomposed by carbonate of baryta, instead of carbonate of lime.

c. To extract the urea in diabetic urine:—Expose a given quantity of urine, mixed with some yeast, to the temperature of  $80^{\circ}$ , in a graduated glass jar inverted over a mercurial bath; we thus get rid of the sugar by fermentation, and can proceed as below (*d*): the quantity of sugar present is also indicated at the same time (33.)

*d*. To estimate the urea in albuminous urine:—Evaporate the urine to dryness in an open steam-bath, treat the residue with boiling alcohol. Evaporate the alcoholic solution and redissolve the extract in distilled water; concentrate this to a syrup, then mix it with half its bulk of pure nitric acid. Place it in a freezing-mixture: the crystallized nitrate is then produced. The supernatant liquid is then poured off, the crystals washed with ice-cold water and dried in the open steam-bath. We may then calculate the amount of urea by abstracting the equivalent of nitric acid from the weight of the crystalline nitrate.

*e*. For the peculiar effect of the presence of urea in altering the ordinary form of the crystals of chloride of sodium, see (13.)

\* These evaporations must not be hurried; if they are, no dependence can be placed upon the results.

† Berzelius.

12. LITHIC ACID exists in the urine combined with ammonia. This compound is deposited from healthy urine under certain circumstances. (9.)

*a. Chem. characters.*—It is soluble in 10,000 parts of cold water, the solution feebly reddens litmus. When pure it is white, but is always coloured when existing as a urinary deposit; insoluble in alcohol and æther; soluble in liquor potassæ and strong sulphuric acid, from the latter of which it is precipitated by water; sparingly soluble in the alkaline carbonates;\* rather more soluble in strong hydrochloric acid than in water; soluble in both diluted and strong nitric acid, equal volumes of gaseous carbonic acid and nitrogen being given off. After evaporating the nitric solution a red extract is left, which becomes of a beautiful purple by the addition of ammonia. This is the purpurate of ammonia, purpurine, or murexide, and is the characteristic of the presence of this acid. Murexide is but slightly soluble in cold water, but colours it of a fine purple; it dissolves in water at  $158^{\circ}$ , and crystallizes on cooling; it is insoluble in alcohol and æther. Urea is formed by the distillation of lithic acid. The crystals of lithic acid are of a yellowish brown colour; the colouring matter is related to that of the bile, as, like it, it becomes of a purple colour by the action of nitric acid. The composition of lithic acid is  $C_{10} N_4 H_4 O_6$ .

*b. Microscop. characters.*—It is always crystalline. As occurring in urine the crystals are always coloured. Their varieties of form are almost endless; the most common only will be noticed. The crystals are either separate or combined into clusters. When separate, the outlines are either rhomboidal, square, or rectangular, and all their varieties appear to me to be clearly explained by assuming them as derived from the right rhombic prism. The most perfect and the largest crystals generally approach nearest to this form. In many cases this prism is very much flattened, so as without great care to be mistaken for a rectangular plate. A cube of lithic acid I have never seen, although I have sometimes been shown what was considered one, *i. e.* a crystal with a square surface; the other surfaces were not seen in these cases, but only imagined. In many cases we

\* Lithic acid is most soluble in carbonate of lithia (1 to 4.)

find the prisms of tolerable length, as in Pl. I. fig. 1; of course here the rectangular outline of the crystal, as it lies on its side, is very distinct (but by moistening any specimens we are examining with water, and then adding a little æther or spirit, currents are produced which cause the crystals to turn over continually and in every direction, so that a full view of every surface is obtained.) In other cases the prisms are extremely short, so as to lie upon one of their flat extremities; here of course the rhomboidal base only is seen, as in Pl. I. fig. 2. In many cases, especially where the acid has been precipitated by the addition of muriatic or nitric acid, the crystals possess a curious hour-glass internal structure; the relations of this are difficult to comprehend. In some cases the two obtuse angles of the rhombic prism are replaced by two semicircular facets, as in Pl. I. figs. 3 and 4. A very curious modification of form is seen in the lithic acid obtained from the guano, or the excrement of serpents; in these we find the crystals are extremely thin, possess the hour-glass internal structure, and are apparently nothing more than delicate tables; but by viewing them when turning over, we can distinctly see that they are the same rhombic prisms very much flattened. In many cases, where the containing urine has been very acid, the crystals are striated, as in Pl. I. fig. 13  $\beta$ ; but in others we find this without any such acidity. The aigrettes and other combinations we so frequently meet with seem irregularly or more hurriedly formed, although sometimes we find them in the urine mixed with the ordinary rhomboids (see Pl. I. figs. 9 and 12.) When we add a few drops of any acid to urine the lithate of ammonia contained in it is decomposed; the acid added appropriating the ammonia, whilst the lithic acid falls in crystals (Pl. I. fig. 1.) This is the ordinary mode of ascertaining the amount of lithic acid present in urine; for this purpose use muriatic or acetic acid, as nitric acid dissolves the lithic acid.

c. Urine containing a deposit of lithic acid is generally minus\* its proper quantity in solution; some acid furnished by the system decomposing the lithate of ammonia in its

\* In the majority of cases of lithic acid gravel the amount of that compound deposited very much exceeds that ever naturally contained in the urine.

passage to the bladder. This is sometimes lactic acid, sometimes phosphoric, and sometimes sulphuric.

The crystals of lithic acid, when examined by polarized light, develop splendid colours; the pure do so beautifully. This is sufficient to show that cubes of this substance cannot exist, inasmuch as it does not belong to the cubic system.

*d.* Calculi composed of lithic acid are generally smooth, or having broadish tubercles; of a brownish-yellow colour, with their layers concentrically arranged; and are readily distinguished by their entire volatility by heat;\* insolubility in water; formation of murexide with nitric acid and subsequent evaporation; solubility in liquor potassæ; and reprecipitation in a pure crystallized state by the subsequent addition of an acid.

13. The fixed salts are chloride of sodium, sulphates of soda and potash, phosphate of soda, magnesia and lime. For ordinary purposes these may be estimated together; they constitute the residue of the incineration of the extract arising from the evaporation of any given weight of urine. They are composed of salts soluble and those insoluble in water. The former are alkaline, the latter earthy salts. A portion of silica has usually been considered as present in urine, but the quantity is so minute, if really existing in health, that it is not worth noticing; it would remain in combination with the earthy phosphates. Should you require to separate the alkaline salts proceed thus:—Divide their solution in water into two parts; acidulate one of these with nitric acid; then precipitate the contained sulphuric acid by nitrate of baryta; the sulphate of baryta falls as a white precipitate† (the other salts of baryta would be dissolved by the nitric acid should they form in the solution;) this is collected on a filter, washed, and dried; it is then weighed, and by deducting the weight of the baryta, we obtain that of the sulphuric acid with which it was combined. (*Vide Table.*)

If the filtered liquor and washings, which are acidulous from the excess of nitric acid added, be saturated with am-

\* There is usually a small quantity of a calcareous residue, but this is foreign to the composition of the lithic acid.

† Amorphous and granular.

monia, a precipitate of phosphate of baryta\* falls; this must be collected and dried on a filter; by abstracting the weight of the baryta we obtain the weight of the phosphoric acid. (*Vide Table.*)

The second portion is used to determine the quantity of muriatic acid present. Acidulate this with nitric acid. (This dissolves the phosphate of silver or the sulphate, should any be formed.) On the addition of solution of nitrate of silver, an insoluble curdy chloride is formed,† which must be collected on a filter, well washed, and then fused. From the weight of this we abstract the weight of the silver, when we obtain the weight of the chlorine present. (*Vide Table.*)

To ascertain the weight of the bases we must add the correct proportions requisite for neutral combination. The sulphuric acid must be divided between potash and soda; the phosphoric and muriatic acids are in combination with soda only.

Table showing the composition of the various salts mentioned above.‡

Phosphate of baryta . . .	Baryta	68.20	+	acid	31.80	=	100
Sulphate of baryta . . .	Baryta	65.63	+	acid	34.37	=	100
Sulphate of potash . . .	Potash	54.07	+	acid	45.93	=	100
Chloride of silver . . .	Silver	75.33	+	acid	24.67	=	100
Chloride of sodium . . .	Sodium	39.66	+	acid	60.34	=	100
Phosphate of soda . . .	Soda	46.70	+	acid	59.30	=	100
Sulphate of soda . . .	Soda	43.82	+	acid	56.18	=	100§

Common salt ordinarily crystallizes in cubes; a peculiar structure is apparent in many of these crystals which gives very much the appearance of octahedra (Pl. II. fig. 28.) When common salt is slowly evaporated from its solution in urine it crystallizes in octahedra, tetrahedra, and in irregular hexagonal plates, &c. (Pl. II. fig. 29.) These latter might be confounded with cystine; but they are readily soluble in water, which cystine is not; and they are not destroyed by a red heat, which cystine is; moreover, we rarely or never see an equilateral hexagonal plate as in cys-

\* *Idem.* † *Idem.* ‡ In the anhydrous state. § Berzelius.



tine. The effect of polarized light would in some instances assist us.

When common salt is crystallized rapidly by evaporation from a solution containing urea, delicate foliaceous crystals are produced, among which the form of the dagger is predominant. This has been proposed as a test of the presence of urea, and may perhaps in some cases be useful. (Pl. II. figs. 30 and 31.)

The presence of soda in any residue of incineration is readily indicated by the blowpipe.\* The ash is moistened with distilled water, and placed in a loop or small coil of platinum wire; by directing the point of the inner flame against this, the outer flame becomes tinged intensely yellow.

Potash is recognised by its concentrated watery solution being precipitated by an excess of tartaric acid, forming a crystalline bitartrate. When examined by the microscope this appears in the form of rhomboidal colourless tables,† sometimes perfect, but ordinarily with truncation of the acute angles; or a spirituous solution of chloride of platinum gives a yellow precipitate, which appears under the microscope composed of aggregations of small prismatic crystals.‡ Both these reagents however give certain evidences of the presence of potash only when the substances suspected to contain it are incinerated; for concentrated ammoniacal solutions produce similar precipitates with these reagents. By the blowpipe the salts of potash yield a violet tinge to the flame.

The mode of separating the magnesia and lime in the earthy phosphates is this:—Dissolve in dilute hydrochloric acid, nearly neutralize by ammonia, warm gently, and then add slight excess of oxalate of ammonia; an insoluble precipitate of oxalate of lime falls; this appears under the microscope either in amorphous granular masses of a dull colour, or when the formation is slower, small brilliant octahedral crystals (Pl. II. fig. 26.) The subsequent addition

\* The antimonite and antimoniate of potassa have been recommended as tests for soda, forming a white crystalline precipitate in its solutions; no free acid must be present.

† Vogel. I have always obtained the bitartrate from urine in the prismatic, not tabular form.

‡ *Id.* These have appeared to me as very minute octahedra.

of ammonia precipitates the phosphate of magnesia.\* This assumes the form given in Pl. I. fig. 18. If we wish to obtain the amount of sulphuric acid present in any product we are examining, it may be done by acidulating as above with nitric acid, and the subsequent addition of nitrate of baryta. The amount of phosphoric acid may be estimated in the residue of earthy phosphates, by dissolving these in dilute nitric acid,† nearly neutralizing by ammonia, and then adding solution of nitrate of silver, when the yellow phosphate is precipitated. This phosphate of silver is composed of 82·99 parts of oxide of silver + 17·01 parts of phosphoric acid in 100.

14. The LACTATES, AMMONIACAL SALTS, and organic matter with them cannot be completely separated; and for practical purposes they are best estimated together. There is most probably free lactic acid in the healthy urine. We obtain the weight of these matters in an analysis thus:—Evaporate a given weight of urine over the steam-bath to dryness, weigh the residue. Then incinerate and decarbonize this residue; again weigh; we then know the weight of the destructible portions of the extract; if from this we extract the weight of the urea and lithic acid we shall have the desired weight.

The state in which lactic acid exists in the urine is uncertain. It is soluble in water and alcohol, as are most of its salts. No precipitate is occasioned in its solution, or in that of its salts, by acids or alkalies. Neither lactic acid nor its salts, which occur in the body with alkaline bases, are precipitated by chloride of calcium, chloride of barium, nitrate of silver (although the latter solution becomes troubled after some time in consequence of the silver being re-

\* Or the following method, which is perhaps better, may be used:—Dissolve the two in hydrochloric acid; then add to the solution, first, sulphuric acid, and then sufficient alcohol to form a weak spirituous solution. The sulphate of lime falls as a precipitate; this is washed with diluted alcohol, and separated by filtration; then drive the alcohol off in vapour by a continued gentle heat, after which precipitate the phosphate of magnesia, in the bibasic form, by ammonia.

† Acetic acid may be used, but on no account muriatic acid, as this would form an insoluble white chloride, which would quite obscure the yellow phosphate.

duced,) nor by bichloride of mercury. When chloride of iron is added to a solution of a neutral lactate, or to lactic acid saturated by ammonia, the solution does not assume a blood-red colour, nor is oxide of iron immediately precipitated by an excess of ammonia; but after some time a turbidness and gradually a precipitate of oxide of iron falls.\* In very dilute solutions of lactic acid this occurs immediately. When lactates with fixed bases are heated to redness, the base remains in the ash as a carbonate.

Composition,  $C_6 H_5 O_5 + aq.$

In the ordinary state lactic acid occurs as a deliquescent liquid, but by sublimation it may be obtained in crystalline rhomboidal tables.†

It is distinguished from the volatile acids by its not passing over in distillation; also chloride of iron added when the solution is supersaturated with ammonia, does not immediately yield a precipitate of oxide of iron. This last property distinguishes it from the mineral acids. The lactates are more difficultly recognised. We may conclude them to be present when the alcoholic extract, (previously supposing it to be free from salts of volatile or fatty acids) which is acid, or at least not alkaline, after incineration, and being moistened with distilled water, is distinctly alkaline (renders red litmus blue.) This means can only be adopted when lactic acid is combined with fixed bases.

*Microscop. characters.*—As it ordinarily exists in the liquid state it presents no particles which can be microscopically recognised, but when crystallized it forms rhomboidal tables.‡

15. LITHATE OF AMMONIA exists in solution in all healthy urine (9.) It has been before noticed as sometimes being precipitated in health, when the quantity of water is not sufficient to retain it in solution. We now notice it as an abnormal ingredient, *i. e.* where it continues to be secreted in excess. It is the chief component of the lateritious sediments. Its colour varies from a perfect white to a beautiful pink.

\* Vogel.

† This sublimate is composed of  $C^6 H^4 O^4$ ; or lactic acid—2 at. water.

‡ Turner's Chemistry by Liebig and Gregory.



*a. Chem. characters.*—It is entirely soluble in boiling water, and in 480 parts of cold, and by evaporation yields crystalline needles; also in warm dilute acids, lithic acid being precipitated; also in solution of potash, as well as in solutions of the alkaline carbonates: it gives off ammonia when heated with potash;\* is entirely dissipated at a red heat; and when dissolved in dilute nitric acid and evaporated, the addition of ammonia devolves murexide or purpurine. It is white when pure. The sediments containing this lithate have been divided into—1st, the yellowish or nut-brown; 2d, the reddish-brown or lateritious; 3d, the pink; and we ought to add to these, 4th, the white; but these discriminations are perfectly arbitrary, although convenient for reference or description; but it may be found of every variety of colour included within the above limits. These sediments often contain lithate of soda, the crystalline form of which is represented in Pl. I. fig. 14;\* and sometimes lithate of lime in small proportion. The nature of the colouring matter with which they are combined is also not determined; some say the cause of the colour is the purpurate of ammonia or murexide; others a peculiar colouring principle, purpurine.

When urine which contains lithate of ammonia in excess is boiled for some time, a peculiar organic insoluble compound forms in it, the nature of which is not well known. It is quite insoluble in nitric acid. There is no albumen in the urine under these circumstances.

*b. Microscop. characters.*—It is nearly always amorphous; I never saw more than a single natural crystalline specimen, and that I have in my possession; it is figured in Pl. I. fig. 14. The radiating needles seen upon its surface have been described as composed of superlithate of ammonia, but I have not obtained enough to enable me to speak positively on this point.

*c. Calculi composed of lithate of ammonia are generally small, and of a clay colour, with a smooth surface; they*

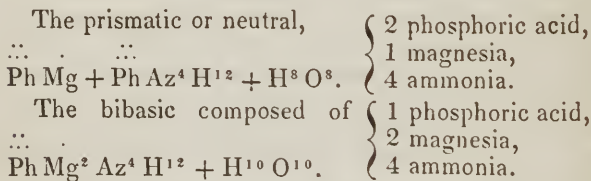
\* The ammoniacal fumes may be detected by,—1st, their odour; 2d, their forming dense white vapours when a glass rod dipped in muriatic or nitric acid is held over them; 3d, their rendering moistened red litmus paper blue.

do not possess concentric layers; they are distinguished by their chemical characters. (9)

Should lithate of soda or lime be combined with the lithate of ammonia, it would not be entirely dissipated by heat, but an alkaline ash would be left: this should be dissolved in a little dilute muriatic acid. If lime be present, the addition of oxalate of ammonia would throw it down as an insoluble oxalate; if soda only, no such precipitation would occur; but by evaporation we should obtain the crystals of common salt. When heated before the blow-pipe, if soda be present, it would communicate a yellowish tinge to the flame; if lime, a pale reddish purple.

16. PHOSPHATES.—In healthy urine we have present the phosphates of magnesiā, lime, soda, potash, and ammonia; for the separation of these see (13 and 14.) To detect phosphoric acid in urine see (13.)

a. When solution of ammonia is added to urine the whole of the phosphates is precipitated; and if we examine the precipitate microscopically, we find it composed of an amorphous part,—the phosphate of lime, and a stellar crystalline part,—the triple phosphate. When ammonia is formed slowly in the urine, as by the decomposition of its urea, the triple phosphate is produced in prismatic crystals, occasionally mixed with stellæ, but these are very few. We have then two forms of triple phosphate; a neutral—the prismatic; and a bibasic—the stellate. These are composed of\*



b. *Chem. prop.*—Triple phosphate is insoluble in water, readily soluble in dilute acids, and precipitated by excess of ammonia in the bibasic form. It is insoluble in liquor potassæ. When heated with potash the ammonia is given off; it is very difficult of fusion.

\* Vigla.

*c. Microscop. char.*—The bi- or sesqui-basic triple phosphate is composed of minute, elegant stellæ, as in Pl. I. fig. 18; it is seldom found as a natural deposit, but it may often be detected in urine which has become alkaline by keeping.

The neutral is found in the form of beautiful prisms, the most prominent varieties of which are seen in Pl. I. fig. 15. Sometimes the angles are replaced by facets. These crystals are easily recognised by their transparency, absence of colour, and peculiar forms. They are found naturally in both acid and alkaline urine; in the cases of alkaline urine the secretion doubtless becomes so after being secreted. I do not believe urine is ever secreted as an alkaline fluid. I have imagined that the peculiar form of crystal (Pl. I. fig. 17) has generally predominated in the phosphates deposited from acid urine. Urine depositing the phosphates is usually pale in colour and low in specific gravity.

When examined by polarized light, the neutral phosphate produces the most brilliant colours, forming one of the most splendid microscopic objects. The stellar bibasic triple phosphate produces little or no effect with polarized light.

*d. Phosphate of lime.*—This is precipitated from the urine when either solution of ammonia or potassa is added to that fluid; it is then mixed with the triple phosphate of magnesia in the former case, and with the phosphate of magnesia in the latter.

*Chem. char.*—It is soluble in dilute mineral acids, and precipitated from these solutions by ammonia. When the solution in acid is nearly neutralized with ammonia and warmed, the addition of oxalate of ammonia gives a precipitate of oxalate of lime. It is exceedingly difficult of fusion. It may be separated from the triple phosphate by digestion in dilute acetic acid, which dissolves the latter, leaving most of the former.\* Dilute sulphuric acid also separates triple phosphate by dissolving it, leaving the lime as an insoluble sulphate.†

*Microscop. char.*—Generally amorphous when existing

\* Scharling. The recently precipitated phosphate of lime is soluble in acetic acid.

† *Idem.*

in urine as a natural deposit, or when hastily precipitated; but found in the urine after decomposition by keeping in a crystalline state (Pl. I. fig. 18.\*)

e. Urine containing excess of the phosphates is often rendered turbid by boiling, so as to resemble in that respect urine containing albumen. It has hitherto been said the addition of a drop or two of nitric acid distinguishes the two, dissolving the phosphate, and leaving the albumen. This however takes place equally in both cases, unless the quantity of albumen be very considerable. It may thus however be distinguished:—When a phosphatic cloud is produced by boiling the urine, a drop or two of nitric acid dissolves the cloud, as with albumen in small quantity, but in the former case the further addition of a few drops does not cause the precipitate to reappear, as is the case with albumen. This will distinguish the two.

The precipitate of phosphate deposited by heat is amorphous. It has been stated by a French author, that the opacity of the urine caused by heat, and not albuminous, is produced by the deposition of the subcarbonate of lime, sometimes of magnesia, deprived of the carbonic acid retaining them in solution. This has never been the case in any of the specimens I have examined. It would be readily detected by allowing the precipitate to subside, washing it, and adding a dilute acid; if it were in the state of carbonate, effervescence would take place; this would not occur if it were composed of phosphates.†

f. *Calculi composed of the phosphates*.—The triple phosphate rarely composes entire calculi; nor does phosphate of lime, except in the case of prostatic calculi, which are almost entirely composed of it: the most common form is the mixture of the two, forming the fusible calculus. Triple phosphate, when heated before the blowpipe, is exceedingly difficult of fusion; the phosphate of lime is more so; the mixture of the two forms an exceedingly fusible compound, thus denominated the fusible calculus. These are usually

† You must not add the acid to the urine containing the precipitate after boiling without washing it; for all urines give off bubbles or effervesce under these circumstances. May not this formation of bubbles and solution of the precipitate by the addition of an acid have caused the author's error?

very white and soft, often containing crystals of the neutral triple phosphate sparkling on their surface, or in their interior. The two phosphates can be thus separated. Dissolve the powdered calculus in diluted hydrochloric acid; nearly neutralize with ammonia, warm the mixture, then add solution of oxalate of ammonia, this precipitates the oxalate of lime; let this entirely subside (this subsidence often takes some time;) by adding solution of ammonia in excess, we then get the bibasic triple phosphate.

II. Constituents not existing in the healthy urine, but found normally in certain parts of the healthy body.

17. BLOOD.—The colour assumed by the secretion containing blood varies according to the quantity contained; we never see bright florid blood in this secretion; sometimes it is almost pitch-black; sometimes of the colour of Port wine; at other times the colour is only slightly deepened, the coagula of fibrin lying at the bottom of the containing vessel. Occasionally the secretion is acid, but generally alkaline.

*a. Chem. char.*—When boiled the albumen is coagulated, and the venous red colour exchanged for that of chocolate; the fluid is decolourized, or nearly so, and the coagula assume the chocolate tint. Nitric acid causes a copious precipitate. It also becomes brightened in colour by the action of a strong solution of chloride of sodium, but this test is valueless compared with the former.

*b. Microscop. char.*—In some cases, where the amount is small, recourse may be advantageously had to the microscope for its detection. The blood-globules may be generally perceived, although many of them become much altered by remaining in the urine any length of time; they become granular on the surface, but however retain their characteristic yellow colour, and some of the unaltered ones may always be found with them. (See 23. *b.* and Part II. BLOOD.)

18. BILE often exists in the urine; when its passage through the biliary ducts is obstructed, it may readily be detected in this fluid. We recognise it by the free presence of its peculiar colouring matter, and the modifications



this undergoes when acted upon by chemical reagents. The urine becomes of a deep reddish-brown, yellowish, or greenish tint: it stains linen yellow. Sometimes it assumes a sedimentary form, and can be separated by filtration. The colouring matter of bile is insoluble in water and alcohol, but readily soluble in caustic potash. When muriatic acid is added to urine containing bile it becomes green; nitric acid produces first a green, then a brownish, and lastly a reddish tinge. (See Part II. BILE.)

19. ALBUMEN.—The urine very frequently contains this principle; sometimes it appears for a time and then disappears entirely; at others it remains constantly present. The secretion, when it occurs, generally contains a very considerable amount of epithelial scales, and a number of granules or globules, not unlike those of pus.

*Chem. char.*—It may readily be detected by boiling the urine, when it falls as an opaque white cloud; sometimes merely an opacity is produced, at others the urine becomes almost solid. As the phosphates when in excess are precipitated by heat, we must make use of a reagent to be sure we are correct in determining its presence. It has, I think, been quite overlooked by chemists, that albumen is redissolved by nitric acid much in the same manner as the phosphates, but such is the case; and when the quantity of albumen present is small, the appearances presented by the two are not very dissimilar. They cannot be mistaken however if attention be paid to the following circumstances. A deposit of albumen by heat (when not very abundant) is redissolved by a drop or two of nitric acid; so is the phosphatic cloud; on continuing to add more nitric acid to each, the albumen reappears; not so with the phosphates, they are permanently dissolved; moreover, a very minute quantity of acid will dissolve the phosphates, much less than is required to dissolve the albumen. You must by no means trust to solution of alum or bichloride of mercury, as has been recommended, for these reagents precipitate nearly all urines, and although the appearances produced by their effects are different from those where albumen is present, as they are liable to fallacy they should be avoided. The most delicate test of albumen is the formation of a precipi-

tate by the ferrocyanide of potassium after the addition of a few drops of acetic acid.\* It is not precipitated by heat when excess of free or carbonated alkali is present, or when a large quantity of acetic or phosphoric acid is present.

Another substance has been noticed† as occurring in the urine under certain circumstances, which might by a very careless observer be mistaken for albumen, inasmuch as it is precipitated by the addition of nitric acid. It is not however thrown down by heat, and thus it is not very likely to be mistaken; moreover, the peculiar odour communicated to the urine under these circumstances would apprise us of its probable existence,—I allude to a peculiar resinous compound found in the urine of those patients under the influence of copaiba. I must also merely mention here, although it is not likely to be made use of as a test, that the phenomena of circular polarization of light can be developed in albuminous urine.

Albuminous urine is generally most loaded after the completion of digestion. Very low in sp. gr.; sometimes however in recent cases, and where it is combined with high fever and suppression of the cutaneous functions, it becomes very high in sp. gr., and loaded with lithates and urea. In these cases upon heating the urine, the lithates are first dissolved, and then upon the continuance of the heat the albuminous cloud appears. It is usually deficient in the ordinary amount of urea and lithic acid. The fluid has also a dull muddy aspect, which is considered by some persons as almost diagnostic. In those cases of albuminous urine arising from other causes than granular kidney, the mucous globules and epithelial scales are usually much less numerous than in the confirmed organic disease.

*Microscop. char.*—An amorphous, granular-looking cloud, or precipitate. This urine invariably contains a number of globules, not unlike those of pus, as well as a large number of epithelial scales.

20. OLEO-ALBUMINOUS URINE is not by any means common. It was first accurately described by Dr. Prout, and was called by him chylous urine, inasmuch as he considered

\* This cannot be depended upon alone, for the other protein compounds, fibrin and casein, are also precipitated by this reagent.

† Dr. Rees, Medical Gazette, December 1840.

it to owe its peculiarities to chyle passing into the blood without undergoing farther elaboration, and being discharged, like other foreign matters, from the circulation by the kidneys. It resembles milk in colour and consistence. It is commonly acid, and decomposes more readily than natural urine. By standing it sometimes coagulates, sometimes continues homogeneous. It is coagulated by heat, and when acidulated with acetic acid, yields a precipitate to ferrocyanide of potassium. It contains fatty matter, which can be separated by agitation with æther. [For a minute account of the properties of chyle *vide* Part II. CHYLE.]

21. A SIMPLE OLEAGINOUS OR FATTY MATTER has been occasionally found in the urine, forming a pellicle or scum on it a short time after having been passed. This has been supposed to arise from steatomatous tumours adhering to the inside of the bladder. It is rare, and has doubtless in some cases been added for the sake of imposition on the part of the patient. It would be readily distinguished by its peculiar appearance, the large size of the oil-globules, and the absence of all milkiness or opacity.

22. SEMEN.—When this is present in urine the mucous cloud is increased and is more dense. The urine becomes very slightly albuminous,\* and by decanting the fluid part of the urine, and examining the sediment under the high powers of a microscope, the spermatic animalcules may be perceived, (Pl. II. fig. 33.) *Vide* SEMEN, Part II.

III. 23. Principles occasionally found in the urine, but never existing in that fluid in health, nor in other fluids of the healthy body.

a. Various abnormal and remarkable colouring matters have been occasionally found in the urine, sometimes forming a deposit, sometimes in solution. Blood has been noticed. (17) Prussian blue (sesquicyanide of iron) and indigo have both been detected. Indigo would be distinguished by washing the sediment composed of it well with water, and drying it, when by heating it to between 500° and 600° it would be sublimed in acicular crystals. Prus-

\* Becquerel.



sian blue would be readily recognised by boiling it in solution of potash, when, upon the subsequent addition of a solution of perchloride of iron, the blue colouring reappears; this is not the case with indigo.

*b.* A blue colouring principle termed cyanourine has been also found in the urine. This is turned red by acids, and on neutralizing the acid by an alkali the original blue tint is restored. Caustic potash has little or no effect on it.\* Various articles taken into the stomach alter the colour of the urine, such as madder, beet-root, rhubarb, &c. In some cases the red colour produced by some of these has been mistaken for blood. They would be readily distinguished by the absence of the peculiar effects of boiling; (17) in these cases the colour is not destroyed by heat; moreover, by adding liquor potassæ to such urine, a green colour is produced; this is destroyed on neutralizing the alkali by an acid, and the original tint reappears.

*c.* The various shades of colour produced when the urine is loaded with the lithates have already been noticed; (15 *a*) sometimes the quantity of colouring matter combined with the lithate of ammonia is so great as to make the urine appear almost black. A peculiar black substance has also been noticed, which became developed after the urine had been passed, and has been denominated melanic acid; but it is so rare as hardly to require mention.

24. Many dietetic articles also impregnate the urine with their odoriferous principles; some of these become altered in their passage through the system. Essential oils, balsams, onions, asparagus, coffee, &c., can be detected in this manner. The ready communication of the odoriferous particles of food to the urine would indicate mal-assimilation. Oil of turpentine communicates a powerful odour of violets to this secretion.

25. Salts in passing through the system are in some cases decomposed, in others they remain unchanged. Thus the tartrate, citrate, and acetate of soda or potash become converted into carbonates. The vegetable acids appear united with bases; whilst the mineral salts pass through the system, and appear in the urine unchanged.

\* Braconnot.

Iodine, taken internally, appears in the urine as an iodide or an iodate,\* and may be readily detected thus:—Add to the secretion a few drops of nitro-muriatic acid, or a solution of chlorine, and then a cold solution of starch; the blue iodide of starch immediately appears. In some cases it is requisite to evaporate the urine to dryness, then to boil water on the residue; this solution, tested in the same manner, produced the same effects.

Quinine and mercury are said also to have been found in the urine.

26. **HIPPURIC** or **URO-BENZOIC ACID** appears in the urine when benzoic acid has been taken internally; it never exists in the healthy secretion. It is obtained on concentrating the urine by slow evaporation, and then adding muriatic acid, when it is precipitated in the crystalline form (Pl. II. fig. 40.)

I have never been able to detect hippuric acid in the urine of children, although it is stated to exist there. I fear there is some mistake in this matter.

*Chem. char.*—Uro-benzoic acid is soluble in 400 parts of cold, and in a small quantity of boiling water; soluble in alcohol, sparingly soluble in æther; dissolves without change in muriatic acid. Nitric acid converts it into benzoic acid.

It is composed of C 18, N, H 9, O 6.

*Microscop. char.*—The crystals are long four-sided prisms, whose modifications are seen in Pl. II. fig. 40.

It may be distinguished from benzoic acid by its crystalline form. The latter crystallizes in aggregated hexagonal needles of pearly scales, and is soluble in 2 parts of sulphuric æther, whereas hippuric acid crystallizes in isolated four-sided prisms, and is very little soluble in æther.

27. **NITRIC ACID** has been sometimes detected in the urine, and its action upon the lithic acid has been supposed to be the cause of the production of the purpurate of ammonia or murexide, which colours the beautiful pink deposits. It would be best thus detected:—Neutralize any free acid by potash; evaporate to dryness; dissolve the

\* Generally, if not always, as the latter; inasmuch as on boiling alcohol on the residue of evaporation the iodine is not removed.

residue in a small quantity of water; add a little sulphuric acid, and then a green crystal of protosulphate of iron. If nitric acid be present, it will be decomposed, and the resulting nitric oxide passing through the water containing the protosulphate in solution will cause the formation of a black deposit or cloud around the crystals.

28. **OXALIC ACID** when added to urine forms an insoluble oxalate of lime, so that should it be present at any time it would unite with the lime always existing in urine, and form an insoluble compound. Should it be suspected to exist free, or as a soluble oxalate, it might be detected thus:—Add a solution of chloride of calcium to the suspected urine or solution; if oxalic acid be present, an insoluble precipitate would be formed; this would be distinguished from the sulphate of lime by its solubility in nitric acid, and from the phosphate or tartrate, &c. by its insolubility in a small quantity of hydrochloric acid, which these are; it is, however, soluble in considerable excess. Wöhler has observed oxalate of lime in the urine after oxalic acid had been taken internally, and Donn  has observed that after eating sorrel the urine has become filled with crystals of the same compound.

29. **OXALATE OF LIME.**—This in the form of a crystalline deposit is not nearly so rare as was formerly supposed;\* it is often combined with the lithates.

*a. Chem. char.*—Insoluble in liquor potass , also in acetic acid. When incinerated, carbonated and caustic lime are left. By boiling with excess of sulphuric acid the oxalic acid may be separated and recognised by its peculiar character, which is the formation of a white precipitate, soluble in nitric, but not in a small quantity of muriatic acid (28).

By boiling oxalate of lime in solution of carbonate of potassa double decomposition takes place, carbonate of lime is precipitated, and oxalate of potassa remains in solution.

*b. Microscop. char.*—When present in the urine it occurs in crystals, whose form is a very flat octahedron. As they lie upon the field of the microscope they appear to have a rectangular, or sometimes a square outline. When dry

\* This was first pointed out by Dr. Golding Bird.

they appear to have a smaller square placed within the larger, whose sides are opposite the angles of the latter; this arises from the lateral rays being refracted beyond or without the field of the microscope (Pl. II. fig. 22.) When moist they appear as in Pl. II. fig. 21. But their true form can only be shown by placing them, when gently moistened in æther or spirit, and then examining them under the microscope. Sometimes they appear in the form of what Dr. Bird has called dumb-bells (Pl. II. figs. 24, 25,) or sometimes a modification of them, which I have found, as in Pl. II. fig. 24.\* By polarized light the dumb-bells give the most splendid colours; whilst the octahedrons produce very little, sometimes no alteration.

c. Urine containing oxalate of lime is extremely various in its characters; sometimes it is very pale, at others loaded with lithates, and high-coloured.

d. Calculi composed of oxalate of lime, or mulberry calculi, are invariably tubercular upon the surface, of a grayish-brown tint, very hard and dense; sometimes the surface is covered with sparkling crystals of the same composition. When urate and oxalate of lime are combined, they may be conveniently separated by digesting the powdered calculus in a large proportion of dilute hydrochloric acid, which dissolves the oxalate alone and unchanged; the lithic acid is precipitated, whilst the lime with which it was united combines with the excess of hydrochloric acid. The liquid must be filtered to get rid of the lithic acid, and by saturating the clear fluid with ammonia, oxalate of lime is precipitated. The remainder of the lime resulting from the decomposed urate will subside on adding oxalate of ammonia.† Before the blowpipe oxalate of lime chars, and on continuing the heat a white ash is left; this is alkaline, and effervesces with acids. It may be shown to be lime by dissolving in a small quantity of dilute muriatic acid, and adding solution of oxalate of ammonia, when the insoluble oxalate is thrown down.

30. CARBONATE OF LIME sometimes occurs as a urinary deposit, always however as a secondary production, being formed from the decomposition of the calcareous salts by

† Scharling.

the carbonate of ammonia resulting from the decomposed urea. A small quantity is occasionally found in urine loaded with phosphates; it is also found in calculi, chiefly mixed with other ingredients. It would be readily distinguished by its solubility with effervescence in dilute muriatic acid, the solution being precipitated by oxalate of ammonia. It has been said to be the cause of the precipitate formed in urine by heat not albuminous; this, however, I believe to be incorrect. *Vide* (16e.)

31. CYSTIC OXIDE is of exceedingly rare occurrence, but is sometimes found as a urinary deposit, sometimes as a calculus.

*a. Chem. char.*—It is soluble in dilute nitric, sulphuric, muriatic, oxalic, and phosphoric acids; and is insoluble in acetic, citric, and tartaric acids and alcohol; also soluble in ammonia and the caustic alkalies, and in the fixed alkaline carbonates; but not in the carbonate of ammonia. It is entirely dissipated by heat, giving off a characteristic odour. It is nearly soluble in water. By the spontaneous evaporation of its ammoniacal solution it may be obtained in crystals.

Composition,  $C_6H_6NS_2O_4$ .

*b. Microscop. char.*—Cystine generally crystallizes in delicate six-sided plates, sometimes in quadrilateral plates; sometimes the crystals are crenate at the margin, with a dark nucleus; and often we can perceive irregular laminæ on their surface.

Their effect with polarized light is very various; sometimes we have colour developed, but often none.

*c.* Urine containing cystine has a greenish tinge, and an odour of sweet-briar. In putrefying this urine exhales sulphuretted hydrogen. Cystine is precipitated from urine by the addition of acetic acid.

*d.* Calculi composed of cystine are generally covered with smooth tubercles, and have a waxy appearance. When recent they are brown, but become gray or green by keeping. They have no concentric layers.

32. Pus is occasionally present in urine. When in large quantity and unaccompanied by mucus, or when mixed with blood, it may generally be supposed to be derived from an abscess; but when mucus is in excess, or



has preceded the pus, most probably it is derived from the urinary mucous membrane. When present in urine it renders that fluid albuminous, and gives a yellowish or greenish tinge to the sediment which it composes; it can easily be diffused through the urine by agitation, and would be readily distinguished from mucus by its want of tenacity or viscosity, and by the large number of globules which float in its albuminous liquid. Urine containing pus has little tendency to putrefy. When pus is acted upon by ammonia it becomes converted into a viscous gelatinous mass, which depends upon the union of the ammonia with the fatty matter of the pus.

*Microscop. char.*—The peculiar globular granular particles can be readily perceived by a good microscope; they are several times larger than those of the blood, almost colourless; these characters would distinguish them when in small quantity from those of blood, which are entire, smooth, yellow, and flattened. When acted upon by acetic acid they leave distinct nuclei, which vary in number. *Vide* Part II. BLOOD and Pus.

33. SUGAR.—The presence of sugar in the urine properly characterizes diabetes. The quantity of urine sometimes passed in this disease is almost incredible. It is usually pale in colour, higher sp. gr. than 1030, of a hay-like smell. If left in a warm place it becomes covered with a frothy white layer, as if its surface had been sprinkled with flour. This is quite characteristic, and when once seen cannot be mistaken. This white froth is composed of a number of minute vegetable organizations which have been denominated *Torulæ*; they occur in all fermenting liquids, and their growth is by some considered in relation to fermentation in the light of cause and effect.\* They are figured in Pl. II. fig. 35: their development is very interesting. When first formed they are very minute spherical globules composed of two coats, and filled with a liquid containing in suspension a number of extremely minute granules; the globules enlarge, rise to the surface, and form the white scum. Some of the internal granules also enlarge, and become distinct nuclei. These continue ex-

\* Turpin.

panding, the primary globule becomes elongated, and one of the enlarged nuclei bursts through the envelopes of the maternal cell and appears as a bud; this enlarges, others increase in the same manner. As the globules enlarge they become elongated, finally forming long, slender, jointed vegetables, as in Pl. II. fig. 35. These contain several nuclei which are ready to bud out in the same manner as their parents have originally done. They seem to increase in two distinct ways; one is the budding process above mentioned, the other is the division of the parent cell. It is first divided by the increase of two, three or more nuclei into as many separate parts. It then becomes contracted opposite the spaces between the continuous extremities of the internal young cells, finally forming distinct and independent plants, capable of further propagation in a similar manner.

The quantity of urea present in diabetic urine was at one time considered to be less than natural, but this has since been proved to be incorrect by the experiments of Mr. MacGregor.\* The mode of detecting it is described at (11 d.) The amount of sugar may be estimated by fermentation (*id.*;) each cubic inch of carbonic acid gas produced corresponding to nearly one grain of sugar. It is almost impossible to separate the whole of the urea from the sugar and other animal matters. The sugar in a quantitative analysis is most easily estimated in combination with the lactates and other animal matters. (14)

Crystalline sugar can be thus obtained from diabetic urine:—Add to its solution of diacetate of lead; filter; throw down the lead by sulphuretted hydrogen; filter again, and evaporate to a syrup; by boiling alcohol on this, and allowing it to evaporate spontaneously, crystals will be produced. In many cases it may be obtained merely by evaporating to dryness, &c., without using the acetate of lead. It is composed of C 12, H 14, O 14. When heated with nitric acid oxalic acid is formed; this may be recognised by its appropriate tests. (28)

Diabetic sugar is identical in composition with that of grapes. Its crystalline form is represented in Pl. II. fig. 36.

\* MacGregor, Experimental Inquiry.

It is readily soluble in water and a mixture of alcohol and water, but little or not at all in absolute alcohol and æther.

The quantity of solids in 1000 parts of diabetic urine of different specific gravities may be readily found from the following Table.

Sp. gr. at 50° F.	Solids.	Sp. gr. at 50° F.	Solids.
1031	51·15	1041	67·65
1032	52·80	1042	69·30
1033	54·35	1043	71·05
1034	56·00	1044	72·70
1035	57·65	1045	74·45
1036	59·30	1046	76·10
1037	60·95	1047	77·75
1038	62·60	1048	79·40
1039	64·35	1049	81·55
1040	66·00	1050	83·20*

The phenomena of circular polarization of light are developed in diabetic as well as in albuminous urine.

34. Milk has occasionally been found in the urine; but I believe in all cases it has been purposely put into it. Urine under these circumstances is coagulated by acetic acid, but not by boiling. But by the peculiar globules which would be found in it, we should readily recognise the imposition. (Pl. II. fig. 32. *Vide* Part II. MILK.)

35. XANTHIC OXIDE is of extremely rare occurrence. It is, I think, mostly considered as doubtfully existing as a body *sui generis*. It would be distinguished by its dissolving without effervescence in nitric acid, and its leaving a yellow residue on evaporation, not pink, as in lithic acid. (12a) It cannot be crystallized. It is not precipitated from its solution in potassa on the addition of hydrochlorate of ammonia; this is the case with lithic acid.

36. Calculi have been found composed entirely of animal matter. Their chemical characters resemble those of fibrin, and they are therefore called fibrinous calculi. They resemble yellow wax in colour and consistence.

\* Simon.



*Chem. char.*—Insoluble in water, alcohol, and hydrochloric acid. Soluble in caustic potash, and precipitated by muriatic acid. Soluble in acetic acid by heat, and this solution is precipitated by ferrocyanide of potassium. By the blow pipe they give out a smell of burnt horn, and leave a bulky charcoal.

Composition of Xanthic Oxide,  $C_5 + N_2 + O_2 + H_2$ . /

37. After the urine has escaped from the bladder decomposition soon commences; this it has been previously mentioned appears to be hastened by the presence of the mucus, as it may be preserved from decomposition for a greater space of time when this is removed. In warm weather a urine loaded with urea will become neutral and even alkaline in a few hours. This process is also much hastened when the mucus is in excess; these urines, if not alkaline at the time of passage from the bladder, very speedily become so. The first and most important change noticed is the decomposition of the urea; by uniting with the elements of the water present, it becomes converted into carbonate of ammonia; a portion of the carbonic acid of this escapes; the ammonia unites with the phosphate of magnesia, forming the triple salt. This is always present in a crystalline form in stale urine, adhering to the sides of the containing vessel. The phosphate of lime is partly precipitated in an amorphous form, and a portion of carbonate of lime is also formed. The urine often becomes much deepened in colour, and gradually opaque throughout. A scum invariably forms upon its surface, composed of a peculiar magma of animal matter,\* covered with crystals of triple phosphate. It will be readily perceived from the above account how important it is to obtain the urine fresh and examine it at once; otherwise the patient may be treated as suffering from a phosphatic deposition, which is the consequence of decomposition only.

38. The early formation of a peculiar scum on the surface of urine has been adverted to as a sign of pregnancy. It has been observed by many that an opaque greasy-looking layer begins to form in the urine of pregnant women soon after it is passed; this often takes place whilst the

\* Consisting of very minute granular particles.

urine is still acid, but it very soon after becomes neutral, and then alkaline. As soon as the urine has become neutral this crust becomes covered with crystals of the neutral triple phosphate. This layer or scum has been denominated Kiestein. When it is acted upon by acetic acid the phosphatic crystals are dissolved, and the animal matter is left; when acted upon by ammonia the animal matter is dissolved, and the crystals remain. To observe this appearance, about four or six ounces of perfectly fresh urine should be laid aside in a tall, moderately narrow glass vessel, and a paper cover laid over it, to exclude dust. It should then be placed in a tolerably warm atmosphere. The appearance denominated kiestein would be produced should a crust similar to that above described appear within a day or two. The crust I spoke of formerly as occurring in all urine could hardly be confounded with this, as it appears so much later in the urine. When examined microscopically the crust of kiestein appears composed of very minute globules. When it has remained on the surface of the urine for a few days (this fluid often exhaling a peculiar cheesy odour) it breaks up and falls to the bottom.

It has been stated that the quantity of the salts of lime in the urine of pregnancy is much diminished. I have examined a very large number of urines of women during pregnancy, but I have not found this by any means correct. With the exception of the peculiar fermentation (?) which produces the kiestein, and the peculiar cheese-like odour, there are no characteristics of the urine in pregnancy, and even these are not constant.

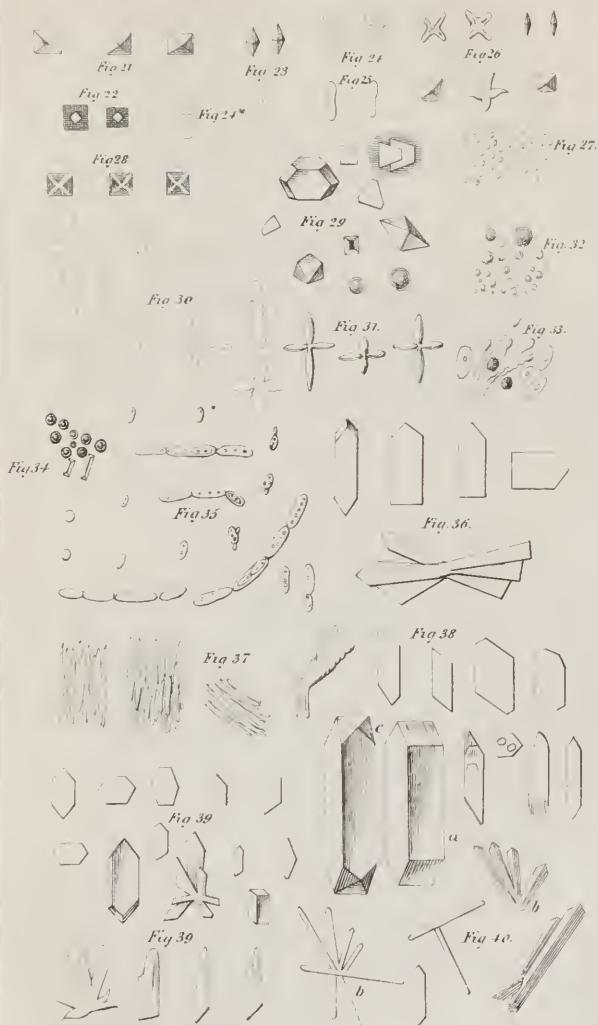
39. In many urines, particularly those which have contained considerable excess of lithate of ammonia by being kept, a number of minute blackish globules appear. I have seen these in urine several times, but unfortunately have not recorded the effects of chemical reagents upon them to determine their nature. I satisfied myself that they were not lithate of ammonia, but I can say nothing more from my own experience. They are sketched from a preparation in my possession. (Pl. II. fig. 34.) The urine in these cases had assumed the peculiar deep brownish-red colour it generally does by keeping.



Plate I.



Plate 2.





## DESCRIPTION OF THE PLATES.

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THE sketches are all made from preserved specimens in my own possession, except when otherwise mentioned. The most common and most readily distinguished forms only are sketched, except where there are some peculiarly interesting features in others. I may say the varieties of form assumed by these crystalline deposits are almost endless.

### PLATE I.

#### *Forms of Lithic Acid.*

- Fig. 1. Form of the crystals of lithic acid as obtained by adding a few drops of an acid to urine. They possess a curious hour-glass internal structure; and their extremities are not entire, but composed of small crystalline needles. The rhomboidal form, when viewed at the extremities, is represented in *a*. Magnified 90 diameters.
2. Ordinary form of lithic acid when occurring naturally as a crystalline sediment. Internal nuclei are here apparent, and in some cases one or both the apices are prolonged into a beak-like form. 90 diameters.
  3. Same deposit; here the obtuse angles are replaced by semicircular facets; side view. 90 diameters.
  4. Same, lying on its face. 90 diameters.
  5. The forms represented here are such as are obtained in precipitating a boiled solution of lithic acid or lithate of ammonia in solution of potash by an acid; this is very pure and colourless; and the internal structure is beautifully developed by polarized light. 150 diameters.

Fig. 6. A modification of the same.

7. A natural form of lithic acid, frequently mistaken for the cubic. They are curiously nucleated, but their rhomboidal forms can be readily detected by examining them in a watch-glass with æther, and &c. 90 diameters.
8. Aggregation of lithic acid prisms. 90 diameters, natural.
9. Foliateous crystalline forms of lithic acid, sometimes occurring in urine with the regular ordinary rhomboids. In some cases they appear tied round the centre as with a string. 90 diameters.
10. Curiously nucleated form of lithic acid, the nucleus retaining the rhomboidal outline. 90 diameters.
11. The same as fig. 3, and having a rectangular nucleus.
12. Modification of fig. 9.
13. Prismatic forms of lithic acid. Here the rhombic prism is elongated, so that these crystals always present a rectangular outline. The true form is discovered by moistening with æther, &c. The rhomboidal outline may often be detected on their extremities, as in  $\alpha$ , and they are often beautifully striated transversely, as in  $\beta$ . 90 diameters.
14. Lithate of ammonia in the globular form; the needles are most probably in the state of superlithate; minute rhomboids of lithic acid mixed with it, and probably resulting from its partial decomposition. Very rare. 300 diameters.
- 14.\* This is the form of lithate of soda. I have twice met with it, it approaches very near to my form of lithate of ammonia (fig. 14.,) but is distinguished by the needles in the former being acute at the extremities, and in the latter obtuse.

### *Forms of Phosphates.*

15. Various forms assumed by the neutral triple phosphate. A trilateral prism with truncated summits appears to be the predominating form. In some cases, one or two, and in others all the angles are replaced by facets. 90 diameters.
16. The same composed of aggregated prisms. This is by no means a common form. 300 diameters.
17. The form of neutral triple phosphate generally found when the urine containing it is acid. 90 diameters.



Fig. 18. Forms of bi- or sometimes called sesqui-basic triple phosphate. 600 diameters.

18.\* Phosphate of lime after Simon.†

### *Forms of Cystine.*

19. These crystals are remarkable for their regular six-sided form. (*a.*,) always having traces of laminæ on their surface (*a*\*,) In some cases their centres are occupied by black masses, as in *b*. Sometimes the whole crystal assumes this form. It then appears composed of an aggregate of minute needles. 90 diameters.
20. Cystine assuming the form of the rectangle. The effect of polarized light upon this is much more striking than upon the six-sided form. In some rare cases the cystine has assumed the form of a semicircular plate, showing beautifully the black cross when examined by polarized light.

## PLATE II.

### *Forms of Oxalate of Lime.*

21. Ordinary form when moist. The outline appears rectangular or square. 300 diameters. Natural.
22. The same when dry.
23. The same viewed edgewise, as seen rolling over in spirit or æther.
24. Dumb-bell form of oxalate. 600 diameters. Natural.
25. The same lying on its side. These appear composed of very minute needles.
26. Represents the oxalate as precipitated from urine by oxalic acid or oxalate of ammonia. 300 diameters.
27. The same, only exceedingly small.

28, 29, 30, 31. *Crystals of Chloride of Sodium.*

28. Crystallized from distilled water. We have here a peculiar appearance which might very readily be mistaken for that of an octahedron.

† I have specimens of this.

Fig. 29. Slowly crystallized from urine. We have here forms somewhat resembling those of oxalate of lime and cystine; but there are no laminae to the hexagonal plates, as in cystine; nor are the sides equal, as in the latter; and the octahedron is not flattened, as in oxalate of lime. Moreover, the solubility of chloride of sodium in water would at once distinguish it from these two.

The figures 30 and 31 are formed when common salt is crystallized rapidly from urine or a solution of urea. They appear generally crenate at the margin, sometimes however quite entire, and of the form of a dagger. 90 diameters.

32. Globules of milk, characterized by their extreme variations in size, absence of nucleus, and spherical smooth surface. It appears to me quite absurd to talk of the "size" of milk-globules as definite, for they are of almost all sizes. 300 diameters.
33. Spermatie animalcules, with epithelial scales and mucus globules,\* found in urine containing semen. 300 diameters.
34. Black globules found in urine by keeping, mixed with crystals of triple phosphate.
35. "*Torula Diabetica*." I do not know of any characters by which this fungus can be distinguished from that found in milk or other saccharine liquids; in fact, I believe they are all the same. 300 diameters.
36. Crystals of diabetic sugar. 90 diameters.
37. Crystals of nitrate of urea. Impure, as ordinarily obtained by adding nitric acid to concentrated urine, or that containing urea in excess. 90 diameters.
38. The same in a more pure and distinctly crystalline form. 90 diameters.
39. Crystals of oxalate of urea. 90 diameters.
40. Crystals of hippuric acid. 90 diameters.

c. Perfect form (Ure.)

$\alpha$ ,  $\beta$ ,  $\gamma$ . Crystallized from alcohol.

Some of these forms are not unlike those of nitrate and oxalate of urea, but the peculiar circumstances under which they are produced would readily distinguish them.

\* From the prostate?

# PART II.

CONTAINING THE

GENERAL, CHEMICAL, AND MICROSCOPICAL

CHARACTERS OF THE BLOOD,

ETC.,

BOTH IN HEALTH AND DISEASE.



## PREFACE TO PART II.

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THIS Part forms the completion of the work. The properties of the substances entering into the composition of the various animal fluids are here entered into rather more fully than in the preceding Part, and their leading characteristics detailed. The results of the numerous analyses which have been made are but rarely noticed, my object being rather to show the manner in which such may be best made. The excellent work of Simon will however be found to supply this deficiency, for in the second volume the most important results which have been obtained in this branch of investigation are contained; and as a translation of it has been issued by the Sydenham Society, it is within the reach of all who are interested in the subject. Organic or ultimate analysis is not treated of, although it is frequently indispensable in the investigation of the nature of animal matters. This was expressly avoided, since distinct treatises have been published on it; and it is moreover usually considered to require too much time and too minute a knowledge of chemical manipulation to come within the grasp of the medical practitioner.

An Appendix is added, into which any discoveries or new processes of importance that have appeared since the publication of the first Part, and which come within the limits of the Manual, are abstracted.

It would be mere waste of time to attempt to detail the advantages to be derived from a more extended examination of the properties of the components of the human body in its normal state of health, and in its deviations from this condition.

The important light which has been thrown upon several points in physiology and pathology by the researches of modern chemistry and microscopy are so striking, that to be alone acquainted with them is sufficient to ensure a due appreciation of their importance. To argue that such investigations are idle, merely because each new truth which is elicited is not immediately applicable to the elucidation of some point in the history of a disease, or to the improved application of remedial means for its alleviation, is as absurd as unfortunately it is frequent. There is however one consolation in this matter, which is, that those who are the most ready to urge these views and to decry the utility of calling in the aid of the collateral sciences, are such as are least acquainted with their details.

In conclusion, if by writing this little book I may at all contribute to excite an increased taste for the cultivation of the subjects of which it treats, I shall feel amply repaid for any trouble bestowed upon it.

9 St. John's Square,  
April, 1846.

GENERAL, CHEMICAL,  
AND  
MICROSCOPICAL CHARACTERS  
OF THE BLOOD, &c.

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BEFORE treating of the characters of the compound fluids, those proximate principles, &c. which are generally diffused through them will be described; those which are found in peculiar fluids only will be treated of with the fluids themselves.

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I. PROTEINE COMPOUNDS.

These substances consist of combinations of an organic principle with sulphur and phosphorus in various proportions; the organic principle itself is called proteine. They exist in two states, a fluid and a solid. In the former they are coagulated by electricity; and after the addition of acetic acid, by solution of ferrocyanide of potassium. When in the coagulated or solid state, they are insoluble in water, alcohol and æther, partly soluble in acetic acid, entirely so in alkalies by heat, and on the addition of acetic acid to the alkaline solution the proteine is precipitated. When boiled with muriatic acid they gradually dissolve, assuming a lilac or bluish-purple tinge. When boiled with water, the base becomes oxidized.

1. PROTEINE does not occur in the solids or fluids of the body in an uncombined state.

*Chemical properties.*—*a.* When carefully dried, it forms a brownish amber-coloured mass, which is hard, brittle, and may be readily pulverized; it absorbs moisture from the air, but may be completely dried at  $212^{\circ}$  F.; when immersed in water, this is absorbed, rendering the proteine gelatinous, and forming semi-transparent flakes. It is insoluble in water, alcohol and æther. When heated, it does not fuse until decomposition commences; it then swells up and evolves the ordinary products of decomposition of nitrogenous bodies. It leaves no ash. By long-continued ebullition with water, it does not yield gelatine, but two substances which have been only recently discovered by the indefatigable Mulder. Proteine combines with acids and bases. It dissolves in acetic acid, and the solution is precipitated by ferrocyanide of potassium;\* it is soluble in very dilute, but precipitated by strong acids,† except the acetic and phosphoric; tannic acid and potash likewise precipitate it from its solutions in acids. On ebullition with dilute sulphuric acid, it becomes coloured purplish-red; with nitric acid, yellow or orange; with muriatic, at first yellowish, then bluish-purple, and ultimately brownish or black. The presence of oxygen is requisite for the production of this change in colour, which is a very characteristic phenomenon. Proteine dissolves in alkalies without change; the resulting compounds are insoluble in alcohol. When boiled with excess of potash, carbonate and formiate of ammonia, leucine, protide and erythroprotide are formed.

Proteine is composed per cent. of carbon, 55.22; hydrogen, 6.99; nitrogen, 15.97; and oxygen, 21.82, giving the formula  $C^{40} H^{30} N^5 O^{12}$ .‡ Its atomic weight is 436.

*b.* Proteine may be obtained by treating fibrine, albumen, caseine, or any substance containing it, with water, alcohol, æther and dilute muriatic acid§ in succession. It is then heated for some time to  $120^{\circ}$  in a moderately strong solution.

\* This precipitate is composed of hydrocyanic acid, proteine and cyanide of iron.

† These are compounds of the acid with proteine.

‡ Liebig assumes the formula  $C^{48} H^{36} N^6 O^{14}$ .

§ These agents remove extractives, fat, salts, &c.



of caustic potash.\* Acetic acid is then added in the slightest possible excess; the precipitate is collected on a filter and washed with distilled water.

c. Proteine forms two oxides:—

α. THE BINOXIDE is left in an insoluble form after fibrine has been boiled with water for some hours; it is purified by ebullition with alcohol and æther, in which it is insoluble. It is soluble in the dilute mineral and acetic acids; ferrocyanide of potassium precipitates it from the acid solution; it is also soluble in solution of potash and ammonia, and does not assume so deep a yellow colour from the action of nitric acid as proteine.

It is composed of 1 atom of proteine + 2 atoms of oxygen, yielding carbon, 53·52; hydrogen, 7·17; nitrogen, 14·80; oxygen, 24·51 =  $C^{40} H^{30} N^5 O^{14}$ .

β. THE TRITOXIDE is formed by boiling fibrine or albumen in water for many hours, precipitating by acetate of lead, neutralizing the solution with ammonia. The precipitates are collected on a filter, and the lead separated by sulphuretted hydrogen; on evaporating the solution, the tritoxide remains. It is soluble in both hot and cold water and in alkalies, but is almost insoluble in alcohol and quite so in æther. It is precipitated by the mineral acids, bichloride of mercury, and both acetates of lead, but not by ferrocyanide of potassium.

It is composed of 1 atom of proteine + 3 atoms of oxygen, yielding carbon, 51·38; hydrogen, 6·78; nitrogen, 15·01; oxygen, 26·82.

d. With sulphuric acid, proteine forms a gelatinous compound, consisting of 1 atom of each constituent; it is called sulpho-proteic acid. When dry, it is yellow, insoluble in water, alcohol and æther, and forms compounds with metallic oxides.

When a solution of proteine (albumen or caseine) in acetic acid is dropped into very dilute sulphuric acid, a flocculent precipitate of subsulphate of proteine is formed; it contains 2 atoms of proteine to 1 of acid.

e. When acted upon by nitric acid, a yellow substance,

\* This removes the sulphur and phosphorus, forming sulphuret of potassium and phosphate of potash.

xantho-proteic acid, remains undissolved, whilst nitrate of ammonia, oxalic and saccharic acids are formed in the solution. It is composed of  $C^{34} H^{24} N^4 O^{12} + HO$ , and is insoluble in water, alcohol and æther.

*f.* Proteine also forms compounds with alkalies and metallic oxides.

*g.* When chlorine is passed through a solution of proteine, proteo-chlorous acid is precipitated in the form of white flakes; it consists of  $C^{40} H^{30} N^5 O^{12} + ClO^3$ , and is dissolved by solution of ammonia.

*h.* *Protide* is of a yellow colour, soluble in water and cold alcohol, but precipitated from its solution by basic acetate of lead, not by other metallic salts or tannic acid. Its composition is  $C^{13} H^9 N O^4$ .

*i.* *Erythroprotide* subsides from its alcoholic solution on cooling, is of a reddish colour, readily soluble in water and hot alcohol, and is precipitated by salts of lead and silver. Its composition is  $C^{13} H^8 N O^5$ .

*k.* There is no peculiarity in the microscopic appearance of proteine.

2. ALBUMEN.—Some observations relating especially to the detection of albumen were made in Part I. p. 38.

*Chem. prop.*—*α. Fluid.*—In this form it is coagulated at  $158^{\circ} F.$ , the temperature requiring to be more elevated as the amount of albumen in solution is less; free alkali or acid prevents its occurrence. Albumen is precipitated by the concentrated mineral acids,\* alcohol, lactic acid, bichloride of mercury,† nitrate of silver, both acetates of lead,‡ alum, protosulphate of iron, chloride of tin,§ and tannic acid. Chromic acid causes a precipitate in a very dilute solution.

\* Phosphoric acid does not cause a precipitate, but metaphosphoric acid does.

† This is composed of albuminate of mercury, muriate of albumen remaining in solution. The latter may be removed by washing with water.

‡ Neutral acetate of lead throws down a part only of the albumen, the diacetate the whole. In the former case, some of the albumen combines with, and is retained in solution by, the acetic acid; in the latter, the whole of the albumen combines with the excess of oxide of lead, neutral acetate of lead remaining in solution. Excess of the diacetate redissolves the precipitate.

§ Excess redissolves the precipitate.

Copious dilution with water also causes a precipitation of part of the albumen.

β. *Coagulated*.—In this state when dried it forms yellowish brittle masses, which when pulverized in a warm mortar becomes powerfully electrical, adhering strongly to the pestle; in cold water it swells, and a very small portion appears to dissolve.\* It is insoluble in alcohol and æther, and is incinerated with difficulty, leaving an ash containing phosphate of lime. It swells into a jelly in acetic acid, and is finally soluble in water, especially when heated. Sulphuric and nitric acids behave to it as to proteine. It completely neutralizes alkalies. The quantity of ash left on incineration varies from 1·3 to 11 per cent. In addition to the principal constituent, phosphate of lime, it also contains a trace of phosphate of magnesia with chloride of sodium and carbonate of soda.

It is composed of carbon 54·84; hydrogen, 7·09; nitrogen, 15·83; oxygen, 21·23; phosphorus, 0·33; and sulphur, 0·68; or proteine, 10 atoms + S<sup>2</sup>, P.†

γ. Albumen enters into combination with acids and alkalies. When solutions of metallic salts are added to it, a compound of the acid and albumen remains in solution, and may be washed away, whilst the metallic oxide combined with another portion remains insoluble. It was formerly supposed that albumen is dissolved in animal fluids by the free or carbonated soda and salts always existing in them; the experiments of Wurtz have however shown that this is not the case, at least in some instances.

δ. To separate pure albumen, add muriatic acid to an albuminous solution until no further precipitate is occasioned, wash away the supernatant liquid with very dilute muriatic acid, dissolve the precipitate in cold water, and throw down the albumen with carbonate of ammonia, collect it on a filter, wash, dry and separate all fat by boiling alcohol and æther; or boil an albuminous liquid, taking care that any free alkali is neutralized, filter, wash and dry the precipitate, then digest it in dilute muriatic acid, and subsequently treat it with alcohol and æther. In quantita-

\* 7 parts in 1000 (Chevreul.)

† The albumen of eggs contains a single atom only of sulphur thus agreeing with fibrine in composition.

tive analysis it may be estimated as the insoluble residue of the digestion of water, æther and alcohol on the dried extract, separation from the earthy phosphates, &c., being effected by incineration.

ε. Albumen, when long boiled with water, yields tritoxide of proteine, a portion of unaltered albumen remaining undissolved. It thus differs from fibrine in the tritoxide being formed at once, without the intervention of the binoxide.

If an albuminous solution be heated in an atmosphere of oxygen, a scum is formed on its surface.

*Microscopical characters.*—See Part I. p. 39.

3. GLOBULINE.—This substance, which occurs in the blood and crystalline lens, is undoubtedly a proteine compound, resembling albumen very closely in its properties.

*Chem. prop.*—α. It is precipitated from its solution by alcohol; the precipitate is insoluble in water, but is partly soluble in boiling weak alcohol, partly separating as the solution cools. It is precipitated from its solution in an alkali by acetic acid, but not from the blood, when freed as perfectly as possible from albumen. A scum forms upon its surface on ebullition.

When solid, it is but little acted upon by alcohol; acetic acid with heat partly dissolves it. In most other respects it agrees with albumen in its properties.\* It is insoluble in alcohol acidified with sulphuric acid. According to Mulder's analysis, it is composed of 15 atoms of proteine + S.†

β. It may be obtained by decomposing the sulphate with finely powdered marble, then dissolving the substance in boiling spirit; (0·915) on cooling it subsides.

4. FIBRINE, like albumen, exists in two states, a fluid and a solid.

α. *Fluid.*—We have but little opportunity of examining fibrine in its naturally fluid state, for as soon as it is removed from the living vessels it commences to solidify. The addition of salts, as sulphate or carbonate of soda, &c., will however prevent this. It is perhaps beyond the limits of this manual to enter into the question, whether the fibrine is really dissolved in the blood and other fluids, or

\* For some further observations on this substance, see "Medical Gazette," vol. xxxvi. p. 184.

† Mulder found the per-centage of sulphur. = 0·272.

whether it exists in a semi-fluid state or suspended in the form of minute particles, the cohering of which causes the apparent coagulation. I have no doubt that the former view is correct; for although minute granules can always be detected in fibrinous and other animal fluids, if a drop of the latter be placed under the microscope prior to coagulation, the fibres or masses of fibrine which are subsequently seen to form are far more considerable than could possibly have resulted from the union of the scattered granules.

*β. Solid.*—In this state, fibrine is almost entirely insoluble in water, alcohol and æther. When dried and free from fat, it forms a yellowish opaque mass; if at all transparent, it still contains fat. It is difficultly incinerated, leaving an ash consisting of about 0·6–0·8 per cent.; this is composed of phosphate of lime, a little phosphate of magnesia, and sometimes a little silica; but it contains neither iron, alkali, nor carbonate of lime. Muriatic acid with heat colours it of an indigo-blue colour. It is much more readily acted upon by acetic acid than albumen. It becomes yellow with nitric acid. Alkalies saturate it as perfectly as albumen. Peroxide of hydrogen added to moist fibrine is decomposed, oxygen being evolved and water formed; this does not occur however if the fibrine has been boiled with water or digested with alcohol; it also happens, in a greater or less degree, with many organic tissues which contain no fibrine. Notwithstanding the similarity between the two, it does not occur with albumen.\* Fibrine usually contains about 2–4 per cent. of fat.

It is composed of 10 atoms of proteine S + P, yielding carbon, 54·56; hydrogen, 6·90; nitrogen, 15·72; oxygen, 22·13; sulphur, 0·36; and phosphorus, 0·33 per cent.

When boiled it is first transformed into binoxide, and subsequently into tritoxide of proteine.

*γ.* Fibrine is most readily obtained by stirring blood immediately after its withdrawal from a vessel with a glass rod; the clot is thoroughly washed with water, being occasionally pressed until it is completely colourless; it is then dried, powdered and exhausted with æther.

*δ.* The means of distinguishing fibrine from albumen are

\* Berzelius.



unsatisfactory. When fluid, the spontaneous coagulation of the former is decisive, although its non-occurrence does not afford positive proof of its absence. When solid, the best characters are the more bluish colour formed with muriatic acid and the greater action of acetic acid.

The cohesion of fibrine varies greatly; sometimes it forms a firm fibrous clot, at other times an almost diffuent granular mass.

ε. *Microscop. char.*—Fibrine exhibits two microscopic forms; one undistinguishable from albumen, the other composed of delicate fibres crossing in various directions. The latter is readily seen in fibrine separated from blood by stirring, or in a drop of blood coagulating under the microscope.

5. CASEINE.—This substance varies somewhat in its properties according to the source from which it is derived.

α. *Fluid.*—It is precipitated by the mineral, acetic and lactic acids,\* but the precipitate is soluble on the addition of excess; it is also precipitated by alcohol, chloride of calcium, both acetates of lead, chloride of tin and chromic acid. When boiled, it is not coagulated, but a scum forms upon its surface; this does not occur however without access of oxygen, as for instance in an atmosphere of carbonic acid. It is coagulated by rennet when sugar of milk is present, but not otherwise; the coagulation is really effected by the lactic acid formed from the decomposition of the sugar. Æther coagulates the caseine in cow's milk, but not that in the human fluid. Ferrocyanide of potassium causes a precipitate in the acetic solution of caseine.

Rochleder states that caseine is nearly insoluble in water, that the soluble caseine in milk is combined with potash, soda or lime, and that its coagulation is nothing more than a separation of caseine, resulting from the combination of the acid with the base of the caseine compound. This is however very improbable; otherwise, sufficient of any acid

\* These precipitates are usually stated to be compounds of the caseine with the acid. M. Rochleder however did not find any material difference on analysis between the precipitated substance, after it had been boiled 15 or 20 times with water, and ordinary caseine. It is however highly probable that by this treatment the compound is decomposed and its acid removed.

to neutralize the alkali present should precipitate the whole of the caseine, which is not the case.

*β. Solid.*—In this state it is yellowish, swells in water, but does not dissolve in it, nor in alcohol and æther. Acetic acid dissolves it, especially with heat. It is acted upon by mineral acids like albumen. Alkalies dissolve and decompose it when concentrated. When incinerated, it leaves an ash containing carbonate and phosphate of lime; of the latter about 6 per cent. in the caseine which has not been treated with acids.

*γ.* The caseine of human milk differs principally from that of the cow in its greater solubility in water, the less perfect precipitation by acids, especially dilute sulphuric, muriatic and lactic. Caseine, like albumen, forms two compounds with metallic salts, one soluble and the other insoluble.

Caseine is composed of 10 atoms of proteine + 1 of S. The absence of phosphorus is a remarkable peculiarity; it yielded carbon, 54.96; hydrogen, 7.15; nitrogen, 15.80; oxygen, 21.73; and sulphur, 0.36.

*δ.* Caseine may be obtained by adding sulphuric acid to skimmed milk, washing the coagulum with water, and decomposing the sulphate with carbonate of lime or lead; the soluble caseine thus obtained however generally contains some of the base used. The lead may be separated by sulphuretted hydrogen. Or the precipitate with sulphuric or acetic acid may be boiled repeatedly and in a considerable quantity of water, washed, dried, and the fat removed by æther.

*ε. Microscop. char.*—Caseine is composed of minute granules, aggregated as in albumen to form flakes or masses of various sizes, but not possessing any characteristic form or appearance.

6. KERATINE is the name applied by Simon to the peculiar animal substance constituting horn, the epidermis, epithelium, nails, hair, &c. Recent experiments have shown that this substance is, in some cases at least, a compound of proteine and its oxides; but as its properties are tolerably definite, the name may be conveniently retained.

*Chem. prop.*—It is colourless when pure, insoluble in water, both hot and cold, also in æther and alcohol. It is



soluble in *liquor potassæ*, partially so in ammonia; also soluble in sulphuric acid, imperfectly so in nitric acid, being at the same time coloured yellow. Acetic acid dissolves merely a trace; ferrocyanide of potassium causes little or no precipitate in the solution. By dissolving hair in potash, rendering the solution as slightly acid as possible, a precipitate of proteine falls; on adding more acid, binocide of proteine is precipitated. It is not known whether the same occurs with all the keratine compounds. When boiled with muriatic acid, the solution becomes reddish-brown.

When incinerated, keratine leaves the same earthy and alkaline salts as albumen or fibrine. In the hair, in addition to these, phosphate of magnesia, silica, and oxides of iron and manganese have been found. The hair, which has received more attention than any other keratine compound, contains sulphur and a very minute quantity of phosphorus. In preparing hair for analysis, it cannot be digested with alcohol or æther, as these agents act upon the sulphur it contains; consequently the state in which the last substance is contained in it must differ from that of the sulphur in albumen, fibrine or caseine, as in these it is not removed by either æther or alcohol.

Keratine in the hair is composed of  $C^{40} H^{33} N^6 OS^{15}$ , giving carbon, 51.529; hydrogen, 6.687; nitrogen, 17.936; sulphur and oxygen, 23.848 per cent. The sulphur averages 5 per cent.

*Microscop. char.*—The appearances presented by the different varieties of keratine relate principally to the extent of its organization; there is nothing characteristic in the substance itself. The structures formed of it, as far as they come within the limits of this manual, will be described with the fluids in which they occur. For descriptions of the remainder, Mr. Paget's "Report,"\* or Henle's "General Anatomy"† may be consulted.

\* "Report of the Results obtained by the Use of the Microscope in the Study of Human Anatomy," Brit. and Foreign Med. Review, July 1842.

† "Allgemeine Anatomie," von J. Henle, one of the volumes of Sömmering's "Anatomie."

## II. GELATINOUS COMPOUNDS.

These substances occur extensively in the human body. They swell and become transparent in cold water, dissolve in boiling water; and if the solution be not too dilute, concrete into a jelly on cooling. They are precipitated by chlorine, tannic acid, many earthy and metallic salts, and chloride of platinum, but not by electricity. They are especially distinguished from the proteine compounds by the addition of ferrocyanide of potassium after acetic acid causing no precipitate, by the action of hot water, and their not being precipitated from their solution by acids.

Chevreul found that a certain quantity of tendon, dried at  $212^{\circ}$ , yielded the same weight of gelatine dried at the same temperature; so that it probably exists already formed in the structures.

7. GELATINE occurs in the bones, skin, serous membranes, cellular tissue, tendons, ligaments and ossified cartilages.

$\alpha$ . Its solution is precipitated by bichloride of mercury, little or not at all by either acetate of lead, copiously by tannic acid, alcohol and chlorine, but not by acids, æther, protosulphate of iron, alum, chloride of calcium, nor alkalies;\* protochloride of tin causes a very slight precipitate.

When solid and dried, it is nearly colourless, horny, and does not exhibit any electrical phenomena on trituration. In cold water it swells, forming a plastic mass; in hot water it dissolves, the solution solidifying on cooling. It is insoluble in alcohol and æther. When incinerated it puffs up, and leaves an ash consisting of phosphate of lime.

It is composed of  $C^{13} H^{10} N^2 O^5$ , yielding carbon, 15.39; hydrogen, 6.64; nitrogen, 18.34; and oxygen, 25.10.

$\beta$ . To separate gelatine, the substance containing it must be soaked in water, frequently squeezed, and well washed on a linen bag; the softened moist mass is heated to  $120^{\circ}$ ; it then becomes fluid, and must be filtered; the albuminous

\* Alkalies sometimes throw down a slight precipitate of phosphate of lime.

and mucus portions are thus separated. In preparing gelatine from bones, the carbonate and phosphate of lime should be previously removed by digestion in dilute muriatic acid.

γ. If gelatine be boiled with excess of caustic potash until ammonia ceases to be developed, leucine and sugar are formed. To separate them, the solution is saturated with sulphuric acid, evaporated to dryness, and alcohol boiled on the residue. The alcoholic solution is then evaporated, and the leucine extracted from the residue by cold alcohol.

δ. *Leucine*, which we have previously noticed in the action of potash upon proteine,\* crystallizes in scales resembling cholesterine. It is anhydrous, readily soluble in water and alcohol, but not in æther. It is not precipitated from its solution by any reagent except pernitrate of mercury.† It is composed of  $C^{12} H^{12} NO^4$ .

ε. Gelatine sugar (glycicolle) crystallizes in rhombic prisms, is readily soluble in water, difficultly so in alcohol, and not at all in æther. It gives off no water at  $230^{\circ}$ . In combination with oxide of lead, it is composed of  $C^8 H^7 N^2 O^5$ . In the crystallized state it contains 2 atoms of water.

ζ. On ebullition with nitric acid, gelatine yields oxalic, saccharic and artificial tannic acids, as also a fat resembling stearine. Leucine and gelatine sugar are also formed by the action of sulphuric acid on gelatine; and the latter likewise by boiling hippuric acid with muriatic acid for some time.

η. The microscopic appearance of gelatine is not characteristic.

8. CHONDRINE.—α. This gelatinous substance is principally obtained from the cornea and the permanent cartilages, as those of the nose, the ears and the trachea, as also from the cartilages of the joints and the ribs. It differs in its properties from gelatine. Its solution is precipitated by acetic and the mineral acids, both acetates of lead, alcohol,

\* It is also formed by fusing potash with caseine.

† Lehmann.

protosulphate of iron, chromic acid, alum,\* chlorine, chloride of tin, tannic acid, protonitrate of mercury\* and nitrate of silver.\* It is not precipitated by alkalies, æther, chloride of calcium, ferrocyanide of potassium, nor bichloride of mercury. It is but little soluble in cold water. When dried, it is transparent and shining. It does not become electrical when powdered.

It consists of  $C^{320} H^{260} N^{40} O^{140} S$ , or per cent. carbon, 49·96; hydrogen, 6·63; nitrogen, 14·44; oxygen, 28·59; and sulphur, 0·38. Mulder regards it as a compound of 20 atoms of chondrine free from sulphur ( $C^{16} H^{13} N^2 O^7$ ), combined with 1 atom of sulphur. When incinerated, it leaves an ash (about 4 per cent.,) consisting principally of phosphate of lime.

β. Chondrine differs principally from gelatine in the action of acids, the acetates of lead, and the solubility of most of its precipitates in excess of the reagents.

γ. It may be obtained from cartilages nearly in the same manner as gelatine from bones, by digesting them, when cut up into small pieces, with water for some time; they are then boiled with water, but for a much longer period than in obtaining gelatine. The chondrine is next precipitated by strong alcohol, the mixture set aside, the alcohol poured off, and the chondrine again dissolved in water.

δ. *Microscop. char.*—The same as those of gelatine.

9. GELATINE OF ELASTIC TISSUES.—α. This is obtained from the middle coat of arteries, the yellow ligaments of the vertebral column, &c., by prolonged ebullition.

Its solution is precipitated by muriatic,† nitric,† acetic† and sulphuric† acids, also by tannic acid, chloride of platinum and both acetates of lead, but not by ferrocyanide of potassium. When solid, it swells up, but is little or not at all soluble in cold water; it dissolves in hot water, but is insoluble in æther and alcohol. It has been analysed by Scherer,‡ who found it composed of carbon, 53·571; hydrogen, 7·026; nitrogen, 15·360; and oxygen, 24·042; thus

\* Those reagents marked with an \* redissolve the precipitate in excess.

† The reagents marked thus, † in excess produce re-solution of the precipitate.

‡ From the middle coat of the arteries.

exhibiting the composition of binoxide of proteine ( $C^{40} H^{30} N^5 O^{14}$ .)

β. It differs from gelatine in its concentrated solutions only, gelatinizing, and in being precipitated by acids; from chondrine, in being precipitated by bichloride of mercury; moreover, the precipitates caused by chloride of platinum, alum and protonitrate of mercury, are soluble in excess of the precipitants, which is not the case with those formed in solutions of gelatine of the elastic tissues. It differs from the solid proteine compounds and keratine by its solubility in boiling water, and from fluid albumen by the reaction of acetic acid.

Mulder remarks that gelatine from elastic tissues has properties which are intermediate between those of chondrine, tritoxide of proteine and gelatine. It seems to be a mixture of them.

γ. Its microscopic appearance is not characteristic.

### III. EXTRACTIVE MATTERS.

These occur in every fluid of the body, and were formerly considered as composed of different organic matters, separable by precipitation with various reagents. They had never been submitted to organic analysis, and their separation in the manner described cannot be perfect, since on precipitating organic matters with salts, decomposition of the salt ensues, a portion of the base falling in combination with some of the organic matter, and the acid liberated or the salt formed retaining either another portion of the organic substance or its combination with the base in solution.

The extractives have been divided into the aqueous, which is soluble in water only; the spirituous, which is soluble in water and dilute alcohol; and the alcoholic, which is soluble in water, dilute and anhydrous alcohol. M. Ludwig has shown that the binoxide of proteine in the extractives of the blood is partly soluble in alcohol, partly not; so that one part would enter into the composition of the aqueous extract,

the remainder into that of the spirituous and alcoholic. As the extractives of the blood have alone been accurately examined, I shall omit any notice of those of other fluids and of the substances which have been separated from them, as no light has yet been thrown upon their true nature. The extractive matters of the blood consist of salts and an animal substance, which M. Ludwig has proved to be binoxide of proteine. It is separated from beaten and strained blood by ebullition and stirring until the coagulum assumes a brown colour, then pressed in a linen cloth and the fluid exactly neutralized with very dilute muriatic acid. It is then again quickly heated to ebullition and filtered. The solution, thus freed from albumen, is treated with 4-5 volumes of alcohol of spec. grav. 0.848, which causes the separation of white flakes. These are washed by decantation with alcohol and æther, then dried, exhausted with water, and again dried in the water-bath. Various salts are usually associated with extractive matters; these are the chlorides of ammonia and sodium, sulphates, phosphates and carbonates of soda and potash, alkali in combination with organic acids or other organic matters, and the phosphates of lime and magnesia.

Chevreul obtained a small quantity of a substance which separated from the spirituous extract in a crystalline form, and Wöhler has confirmed its existence; it is called kreatine. It is inodorous, tasteless, neutral, but little soluble in water, readily so in acids. Its aqueous solution is not precipitated by solutions of nitrate of silver, sulphate of copper or iron, diacetate of lead, nor concentrated solution of chloride of platinum. When heated, it evolves ammonia, phosphorous acid and a yellow gas, which partly solidifies into crystals; the odour of hydrocyanic acid is also perceptible. Chevreul considers that it is probably an ammoniacal salt of an acid with a compound radical.

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#### IV. FATTY MATTERS.

These substances may be divided into two classes;—1st, the fatty acids; 2d, the neutral or saline fats, consisting of acid and base.



The general properties of fatty matters are, that they are lighter than water, render paper transparent, fuse at a lower temperature than that of boiling water, are insoluble in water, soluble in boiling alcohol and æther, being deposited on cooling.

When subjected to destructive distillation, the general products are carbonic, acetic, benzoic, oleic, margaric, stearic and sebacic acids, acroleine and inflammable gases.

The perfect separation of many of the fats is extremely difficult, nor is their qualitative analysis always an easy task. One of the most important characteristics is their point of fusion or solidification, which is found to be tolerably constant in each. This may be ascertained by taking a capillary tube (easily made over a spirit-lamp;) into this a small quantity of the substance is drawn by the mouth; the lower extremity of the tube is then sealed; if the fat is solid at ordinary temperatures, it must be previously fused. The sealed end of the tube is then immersed in water, in which an accurate thermometer is placed, and the temperature of the water must be either raised or lowered (by the addition of hot water or use of freezing mixtures, according as to whether the substance is to be solidified or liquefied) until that point is observed at which the fat becomes either solid or fused. The following table contains the fusing and solidifying points of the fatty matters ordinarily occurring:—

Fatty acids.	Fusing point.	Solidifying point	Neutral or saline fats.	Fusing point.	Solidifying point.
Stearic . .	158°	Below 32°	Stearine . . . .	143°	Below 24° 32°
Margaric	140°		Margarine . . .	118°	
Oleic . . .	....		Oleine . . . . .	....	
			Butyrine . . . .	....	
			Cholesterine .	293°	

## 1. FATTY ACIDS.

10. STEARIC is solid at ordinary temperatures, and occurs but rarely in the human body; it is stated to exist in the free state, and as a soap in the bile.



*Chem. prop.*— $\alpha$ . Inodorous, white and of a pearly aspect; almost insoluble in cold, soluble in boiling alcohol, even when dilute, nearly the whole being deposited on cooling. The alcoholic solution reddens litmus-paper, and is precipitated by metallic salts, the precipitates disappearing when the liquid is heated, again subsiding as it cools.

It is composed of  $C^{68} H^{68} O^5 + HO$ , and per cent. of carbon, 76.53; hydrogen, 12.93; and oxygen, 10.52.\*

$\beta$ . Stearic acid is prepared thus:—Saponified tallow is dissolved in 6 or 7 parts of warm water; 40 parts of cold water are then added, and the mixture set aside in a temperate place; bistearate and margarate of potash are deposited. The whole is filtered and washed with cold water; the mixed fluids are collected, concentrated by evaporation, the free potash therein saturated with tartaric acid; water is then added; the bistearates are then again deposited. The salts, after well-washing, are dried and dissolved in boiling alcohol (0.820;) on cooling, bistearate with a little margarate of potash is deposited. By repeated solution in alcohol and recrystallization, the bistearate is obtained pure. The salt is decomposed by boiling with muriatic acid and water, and the liberated acid is freed from soluble matters by repeated fusion in boiling water.

*Microscop. char.*—Its crystals exist in the form of rhomboidal tables, the obtuse angles being rounded off. When formed tolerably slowly, the crystals are readily detected; but when hurriedly deposited, they resemble some forms of margarine (*vide* Pl. III. fig. 6.)

11. MARGARIC ACID is solid and crystalline, and occurs extensively in human fat combined with glycerine.

*Chem. prop.*— $\alpha$ . But little soluble in cold, readily in hot alcohol, even in hot spirit. The solution reddens litmus, yields precipitates with metallic salts, which disappear by heat and subside on cooling. It is soluble in æther.

Margaric acid is composed of  $C^{34} H^{34} O^3 + HO$ ,† yield-

\* The numbers above adopted are those of Berzelius and Mulder. Redtenbacher and Varrentrapp, however, give  $C^{68} H^{66} O^5 + HO$ , and Gottlieb, in a recent paper,  $C^{68} H^{67} O^6 + HO$ .

† Redtenbacher and Varrentrapp adopt the numbers  $C^{34} H^{33} O^3 + HO$ .

ing carbon, 75·64; hydrogen, 12·86; and oxygen, 11·50 per cent.

β. Margaric acid may be obtained by saponifying human fat or olive oil, decomposing the soap with acetate of lead; the precipitated lead-compound is then treated with boiling æther; the remaining pure margarate of lead is subsequently decomposed by a dilute mineral acid; the margaric acid must then be washed with hot water. It may also be obtained by boiling pure stearic acid with strong nitric acid, or by the destructive distillation of stearic acid.

*Microscop. app.*—The crystals of margaric acid very much resemble some of those of margarine; they form needles, which are sometimes grouped (Pl. III. fig. 5.)

The following table indicates the temperatures at which a mixture of margaric and oleic acid solidifies or fuses:—

Per cent of margaric acid.	Tempera- ture.	Per cent. of margaric acid.	Tempera- ture.
5 . . .	45	50 . . .	111
10 . . .	63	55 . . .	114
15 . . .	81	60 . . .	116
20 . . .	89	65 . . .	118
25 . . .	97	70 . . .	120
30 . . .	100	75 . . .	121
35 . . .	103	80 . . .	123
40 . . .	106	85 . . .	125
45 . . .	108	90 . . .	127

12. OLEIC ACID forms a colourless or pale yellow oil.

*Chem. prop.*—α. It powerfully reddens litmus, is soluble in alcohol and æther even when cold; it is not volatile. When subjected to destructive distillation, sebacic acid is produced and condenses, in the receiver. The production of this substance, which occurs in the destructive distillation of no fat except oleic acid, or such compounds as contain it, affords a valuable and readily-applicable test of its presence.

Oleic acid is composed of  $C^{36} H^{33} O^3 + HO$ ,\* or carbon,

\* Redtenbacher and Varrentrapp adopt the formula  $C^{44} H^{39} O^4 + HO$ . Mulder gives  $C^{44} H^{40} O^4 + HO$ ; the numbers adopted in the text are those of Gottlieb.

76.73; hydrogen, 11.89; and oxygen, 11.38 per cent. Its atomic weight is 273.

Its solution is precipitated by metallic salts.

$\beta$ . Oleic acid may be obtained by decomposing oleate of potash or lead with a mineral acid; it is purified by agitation with warm water, and finally separated from any solid fatty acids dissolved in it by gradually cooling it to  $32^{\circ}$  Fahr. and then filtering.

*Microscop. char.*—Oleic acid appears in the form of highly refractive globules, undistinguishable by the microscope from oleine, butyrine, or the mixtures of fatty substances which remain fluid at ordinary temperatures.

13. BUTYRIC ACID exists in rancid butter, to which it gives its peculiar odour; it also occurs in the contents of the stomach, the secretions of some glands, in the perspiration, and sometimes in the urine. It is a colourless oily fluid of a penetrating, peculiar odour.

*Chem. prop.*—It is readily soluble in water, alcohol and æther, and is precipitated from its aqueous solution by phosphoric acid. It is volatile, distilling over unchanged at a temperature above  $212^{\circ}$ . It remains fluid below  $15^{\circ}$ ; its solution is precipitated by diacetate of lead, chloride of tin and alum, but not by acetate of lead, nor nitrate of silver. Butyric acid stains paper like other fluid fats, but the spot disappears by heat. It is composed of  $C^8 H^7 O^{3*}$  when combined with a base, and in the free state contains 1 atom of water. Its atomic weight is 79. Butyrate of barytes yielded carbon, 31.10; hydrogen, 4.55; oxygen, 15.33; and baryta, 49.02.†

Butyric acid is best prepared by saponifying butter and decomposing the soap by distillation with sulphuric acid. The distilled liquid is then saturated with barytic water, and evaporated to dryness.

The saline mass is composed of two portions. The more soluble portion consists of butyrate and caproate of baryta, the more insoluble portion of Chevreul's caprate of baryta. The salts are separated by boiling the saline mass in five or six parts of water; the solution is set aside to crystallize. The crystallized mass is again dissolved in water and eva-

\* Lerch, Chem. Gaz. vol. ii. p. 377.

† Ibid.

porated to crystallization. The caproate of baryta is first deposited, so that the entire solution solidifies to a paste consisting of minute needles; these are separated by pressure from the ley, which then on spontaneous evaporation deposits the butyrate of baryta in crystalline laminæ; this may be purified by recrystallization, and subsequently decomposed by phosphoric acid.\*

14. SEBACIC ACID.—This substance never occurs in the human body, but as its production on destructive distillation of any fat is a valuable test of the presence of oleic acid, either free or combined, it is well worthy of a notice. It is solid, and forms pearly scales; is soluble in hot water, alcohol and æther, and reddens litmus.

It is composed of  $C^{10} H^8 O^3 + HO$ , yielding carbon, 60·01; hydrogen, 8·81; and oxygen, 31·18. Its atomic weight is 92.

Its alkaline salts are readily soluble in water; the earthy and metallic salts are heavy and insoluble.

It is obtained by subjecting oleic acid, or any substance containing it, to destructive distillation, boiling the product with water, filtering through a moistened filter; the acid crystallizes from the solution on cooling or by evaporation.

*Microscop. char.*—Sebacic acid assumes two principal forms, one prismatic, the other scaly. The former contains within it some curious crystalline bodies resembling nuclei, the latter exhibits large irregular scales, somewhat resembling cholesterine, but not having its peculiar form. (*Vide* Pl. III. fig. 4.)

## 2. NEUTRAL OR SALINE FATS.

These are compounds of the fatty acids with a base, which is generally glycerine, when otherwise it will be noticed under the neutral fat in which it occurs. These are the usual forms in which fats occur in the human body.

15. STEARINE exists abundantly in hog's lard, suet, &c.,

\* Lerch, *l. c.* This author has shown that butter sometimes yields no butyric or caproic acids, but in their place vaccinic acid, the composition of which is nearly equal to the sum of the constituents of the other two. If butyrate of baryta is present, the first crystals which separate do not effloresce.

but rarely occurs in human fat, where it is replaced by margarine; it is solid, white, forming a shining pearly substance.

*Chem. Prop.*—Is insoluble in water and cold alcohol, slightly so in the latter when hot; but little soluble in cold æther, readily so in hot. When dry, it is readily pulverized. Its solution is not precipitated by metallic salts. Stearine is a compound of stearic acid and glycerine. When boiled with an alkali, the latter combines with the acid, the glycerine being set free.

Stearine is a bistearate of glycerine + 2 atoms of water, or  $C^{71} H^{72} O^8$  (Mulder.)

To procure stearine, fat must be subjected to heat so as to liberate the fatty matter: the latter is then treated with an equal weight of æther and strongly agitated; this is then poured off and replaced several times by fresh æther. The æther dissolves out the margarine and oleine. The mass is then pressed in bibulous paper, and the stearine may be obtained pure by recrystallization from boiling æther.

*Microscop. char.*—Stearine does not ordinarily exhibit any defined crystalline form. When deposited on the cooling of its boiling alcoholic solution, it sometimes appears as figured in Pl. III. fig. 2.

16. MARGARINE occurs abundantly in human fat, almost invariably mixed with oleine. It is solid and white.

*Chem. prop.*—It is very slightly soluble in cold, but more in hot alcohol, readily so in hot æther, being deposited as the solution cools. Its alcoholic solution is not precipitated by spirituous solutions of metallic salts.

It is composed of  $C^{57} H^{56} O^4$ . (Mul.)

Pure margarine is procured with great difficulty. The fat or oil containing it should be cooled, and the elaine removed either by filtration or pressure between blotting-paper and subsequent washing with cold alcohol. It may be further purified by recrystallization several times from alcohol.

*Microscop. char.*—It forms stellate groups of crystalline needles, as in Pl. III. fig. 1, (a, c,) or long delicate ramified needles; (b) the crystals are small, and with a low power appear in little tufts.

17. **OLEINE**, when pure, is fluid and colourless, and is with great difficulty perfectly separated from margarine and stearine.

*Chem. prop.*—Soluble in cold alcohol and æther; very much so in them when boiling. It is not precipitated by spirituous solutions of metallic salts, nor is it volatile.

It is composed of  $C^{91} H^{84} O^{11}$ .

It may be procured by pressing the fats and oils which contain it between bibulous paper, after they have been cooled to between  $28^{\circ}$  and  $32^{\circ}$ . The paper is then boiled with alcohol; this dissolves the elaine, which must be freed from the former by heat and washing with water.

*Microscop. char.*—Undistinguishable from elaic acid.

18. **BUTYRINE** occurs in milk, some secretions, and in abnormal cysts. It forms a white or pale yellow fluid.

*Chem. prop.*—It is insoluble in water, but soluble in cold, and especially hot alcohol, as well as in æther. When saponified with potash, butyric, caproic, capric, perhaps oleic and margarinic acids, as also glycerine, are evolved.

It is most probable that some of these substances arise from the decomposition of other fatty matters which are mixed with the butyrine, as the latter is unknown in a state of purity.

It may be procured by melting butter and retaining it for several days at a temperature of  $66^{\circ}$  Fahr.; a considerable quantity of stearine and margarine is then deposited in a granular form; the fluid oil, consisting of butyrine and elaine, is filtered and agitated with an equal volume of alcohol ( $\cdot 796$ ) at  $66^{\circ}$ ; this dissolves nearly the whole of the butyrine. The solution, after evaporation, is slightly acid, and must be digested with a little carbonate of magnesia and water. It is then washed, again dissolved in alcohol, and the latter removed by evaporation.

19. **CHOLESTERINE** frequently occurs in the crystalline state in animal fluids, in solution in the blood, bile, fluid of hydrocele, and I found it in the fluid of uterine hydatids. It also occurs in biliary calculi, the brain, atheromatous tumours, &c.

*Chem. prop.*—It is solid and crystalline, insoluble in water; soluble in hot but little so in cold alcohol; also



soluble in æther. It assumes a blood-red colour from the action of sulphuric acid.

When boiled with nitric acid, cholesteric acid is formed; this is but little soluble in water, readily so in alcohol and æther; fuses at  $136^{\circ}$ , and crystallizes in yellow needles.

It is not saponified by alkaline solutions, but is so by fusion with hydrate of potash. It resembles oleine, stearine and margarine, in being a saline fat, *i. e.* a compound of an acid and base. The base, however, is not glycerine, but a basic resin, which, as well as the acid with which it is combined, has not been sufficiently examined. Cholesterine is composed of  $C^{37} H^{32} O$ .

Cholesterine may be procured from biliary calculi by treating them with boiling water, pulverization, and boiling alcohol on the dry powder; the solution must be filtered whilst hot; the cholesterine is deposited on cooling, and may be purified by treatment with cold alcohol, resolution and crystallization. Ebullition with a little potash removes any fatty acids. It may be obtained from the brain by drying it in a water-bath, exhausting the residue with æther, then with boiling alcohol; as the alcohol cools a white powder falls. On distilling the ætherial solution a residue is left, from which boiling alcohol extracts cholesterine. The alcoholic solutions are mixed, three-fourths distilled off, and the remainder allowed to cool; another white pulverulent fat subsides. The precipitates are treated with cold æther; on the evaporation of the æthereal solution, the cholesterine crystallizes and is purified by solution in boiling alcohol.

*Microscop. char.*—Cholesterine is readily distinguished by its peculiar thin rhomboidal tables or plates;\* the angles are sometimes truncated (Pl. III. fig. 8.)

20. GLYCERINE.—This principle never occurs in the free state, except when artificially formed. It exists in margarine, stearine, butyrine and oleine, in combination with the fatty acids. In this state it is anhydrous, but when set free by saponification, it takes up an atom of water. It forms a syrupy, transparent, yellowish fluid; its sp. gr. at  $60^{\circ}$  being

\* These are generally found floating on the surface of the fluid, although cholesterine is heavier than water.



1·280. It reacts with Trommer's test, as also with Pettenkofer's test, like grape-sugar.

*Chem. prop.*—*α*. It is readily soluble in water and alcohol, but not in æther. It is unchanged by ammonia, acetic acid, bichloride of mercury, either acetate of lead, chloride of tin, alum or tannic acid; but is slightly precipitated by nitrate of silver. It does not crystallize, nor does it ferment with yeast.

*β*. When glycerine is subjected to destructive distillation, acroleine is evolved, and may be obtained pure by the distillation of glycerine with anhydrous phosphoric acid; it is formed during the destructive distillation of no substance except glycerine, or those compounds containing it. For this reason, as well as from its most pungent and irritating fumes, it is a valuable test of the presence of glycerine and most fats.

Anhydrous glycerine is composed of  $C^6 H^7 O^5 + HO$ ; in the ordinary state it contains 1 atom of water. Berzelius regards it as the hydrated oxide of a radical (lipyle,  $C^3 H^2$ ), hence  $2C^3 H^2 O + 3HO$ .

*γ*. Acroleine is liquid, colourless, soluble in water, more so in æther, boils at  $126^\circ$  Fahr., and is lighter than water; it is soon decomposed. It consists of  $C^6 H^4 O^2$ .

*δ*. Glycerine combines with sulphuric acid forming sulphoglyceric acid. This is a thin, colourless liquid, which is readily decomposed, even by evaporation *in vacuo*. It forms readily soluble compounds with lime and baryta.

The lime salt is composed of  $C^6 H^7 O^5$ ,  $2SO^3$ ,  $CaO$ .

It may be procured by mixing one part of sulphuric acid with half a part of glycerine, dilution with water, and the addition of milk of lime until the solution is saturated. The sulphoglycerate of lime remaining dissolved in the filtered liquid is decomposed by oxalic acid.

Phosphoglyceric acid has just been discovered by M. Pelouze, and has been found by M. Gobley in the yolk of the egg, and very probably occurs in the human body. It forms a thick, viscid, uncrystallizable liquid, very soluble in water and alcohol. It contains no phosphoric acid as such, and leaves an acid cinder on incineration.

It consists of  $C^6 H^7 O^5$ ,  $P^2 O^5$ ,  $2CaO$ .

*ν*. Glycerine may be prepared by saponifying fatty mat-

ter with oxide of lead, or any alkali, and water; the water lost by evaporation should be constantly replaced. When the fat is saponified, the glycerine is found in the solution; it must be freed from lead by sulphuretted hydrogen, boiled with animal charcoal and then evaporated.

21. ANIMAL SOAPS.—*α*. These substances are combinations of the fatty acids with the alkalies. They are but little soluble in cold water; more so in hot; slightly soluble in alcohol, especially when hot; very slightly so in æther even when hot. They are decomposed by heating with acids. When the aqueous solutions of the neutral soaps are copiously diluted with water, acid salts are precipitated in a crystalline form, free alkali remaining in solution.

*β*. The alkaline soaps are prepared by boiling the neutral fatty matters for some time with a rather dilute solution of caustic alkali, replacing the water lost by evaporation; at a certain period the mass forms a jelly, which by continued heat, if sufficient water and alkali be present, becomes perfectly clear. The soap is separated from free alkali and glycerine by adding chloride of sodium to it whilst hot, until gelatinous flocculi and a perfectly clear liquid are formed. It may be purified by melting in an alkaline solution of chloride of sodium.

*γ*. The soaps may also be directly formed by gently heating the fatty acids with caustic or carbonated alkalies.

*δ*. The qualitative and quantitative analysis of the fats generally is rather a difficult procedure. The evolution of acroleine on the destructive distillation of the residue of the evaporation of the æthereal extract of any fluid, is sufficient evidence of the presence of fats containing glycerine; as has been stated, this is a product of decomposition of glycerine, which exists in oleine and margarine, the two fatty matters most commonly occurring in animal fluids. Butyric acid is separated by distillation. Such matters as are taken up by æther, and are soluble in water, may be removed by washing the fats with that fluid. The presence of the fatty acids may be proved by treating the alcoholic solution with acetate of lead or copper. The reagents precipitate almost the whole of the fatty acids, leaving the neutral fats, which may be removed by evaporation and the addition of water. The fats must then be saponified; cho-

lesterine is thus left unacted upon. This may be extracted by the action of æther upon the residue of the saponified fat after evaporation. The soaps are then treated with muriatic acid; if the odour of butyric acid is evolved, butyric, capric and caproic acids are present. We can then ascertain with tolerable accuracy the relative admixture of oleic and margaric, or stearic acid by the point of fusion of the remaining fatty matters (p. 74, and 76.) The microscope will also assist in the determination of the nature of the fatty matters. The fluid fats are undistinguishable by its aid from each other, but are so from the solid; cholesteroline is readily thus distinguished. The characters of the others have been detailed (see also Pl. III. fig. 1 to 8.)

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## V. ORGANIC ACIDS.

22. LACTIC ACID.—It is doubtful whether this acid is so generally diffused in the animal fluids as was formerly supposed. Recent experiments have shown that it in all probability does not occur in either the blood or urine. Many of its properties are mentioned in Part I. p. 32. It is but little soluble in æther, and has a more powerful affinity for bases than acetic acid, it therefore decomposes the salts of that acid. We cannot conclude as to its presence, nor determine its quantity from the carbonated alkali found in the ash, as stated in Part I. p. 32, as this may depend upon the decomposition of other substances. Lactic acid reduces the silver in the nitrate to the metallic state when heated with it. The composition of anhydrous lactic acid per cent. is, carbon, 44·92; hydrogen, 6·55; and oxygen, 48·53; when hydrated, C 40·46, H 6·61, O 52·93. Its atomic weight is 81 (*vide* Part I. p. 31.) The crystalline sublimate (*l. c.*) is called lactide.

Lactic acid may be obtained by digesting milk in a state of fermentation with milk, sugar and carbonate of zinc, at a gentle heat; the solution is then boiled and filtered whilst hot; on evaporation a crystalline lactate of zinc is obtained; this is then decomposed by baryta, which is subsequently precipitated from the barytic compound by the careful addi-

tion of sulphuric acid: or it may be obtained by digesting well washed moist caseine with cane-sugar and powdered chalk for some weeks at a temperature of about  $90^{\circ}$ , replacing the water lost by evaporation. The crystalline mass thus obtained is filtered through linen, pressed, dissolved in boiling water, and exposed to the cold, the lactate of lime then crystallizes. This salt may be decomposed by hydrochloric acid.

In detecting lactic acid the following process may be adopted.\* The diluted fluid is boiled with milk of lime in excess, until all fumes of ammonia or coagulable matters are dissipated; it is then evaporated to dryness in a water-bath. The extract is treated with alcohol ( $\cdot 830$ ), the solution filtered, and the bases separated by sulphuric acid diluted with alcohol. Every trace of acid is then removed by digestion with recently precipitated carbonate of lead. The solution is filtered, the lead removed by sulphuretted hydrogen, again filtered, and after slight evaporation, diluted with water, and gently heated with recently precipitated carbonate of zinc and filtered whilst hot. The solution is evaporated to dryness, the powdered residue treated with alcohol, and the solution filtered. When this filtered solution is evaporated to the consistence of a syrup, the lactate of zinc crystallizes; or if strong alcohol be added to it, the lactate is precipitated. The crystals must then be examined as to their peculiar form (Pl. III. fig. 10;) they are usually four-sided right prisms with dihedral summits, but sometimes form mere plates, with two-sided extremities, or are combined in aigrettes.

23. ACETIC ACID.—This acid has been found in various animal fluids, as the bullæ of pemphigus, the saliva of a mercurialized patient, the gastric juice, the perspiration, milk, and in putrid urine.

*Chem. prop.*—As ordinarily occurring, its properties are well known. It is very volatile. Its salts are soluble in water; those found in animal fluids are also soluble in alcohol; and when they are heated with sulphuric acid, the acetic odour is evolved. Acetic acid scarcely alters a solu-

\* M. Enderlin by this process was enabled to detect a very small quantity of lactate of soda which had been added to blood.

tion of iron, but the solution of a soluble acetate renders it of a blood-red colour. When its alkaline salts are incinerated, a carbonate of the base remains. Acetic acid is not affected by nitrate of silver, neutral acetates however cause a precipitate which is soluble by considerable dilution. It boils at  $219^{\circ}$ . Acetic acid is distinguished from lactic acid by its volatility, peculiar odour, and action on salts of iron; the peculiar reaction of lime with lactate of copper may assist us in recognising lactic acid when acetic acid is also present; when lime in excess is added to lactate of copper, the solution retains its colour, a portion only of the oxide of copper being precipitated; with acetate of copper the solution is decolorized, the whole of the oxide being thrown down. From butyric acid it is distinguished by its odour, not staining paper, and its solution not being precipitated by phosphoric acid.

It is composed of  $C^4 H^3 O^3$ , yielding carbon, 47.54; hydrogen, 5.82; and oxygen, 46.64. Its atomic weight is 51.

Quantitatively it may be estimated by distillation; the distillate is to be neutralized with baryta, excess of this removed by carbonic acid, the solution is then gently heated, evaporated to dryness, and the weight of the acid estimated from that of the residue; or it may be incinerated and its amount calculated from that of the carbonate left. To separate it from the acetates, evaporate the solution to dryness and then distil it with sulphuric acid, and proceed as above.

24. HYDROCYANIC ACID.—We have no satisfactory evidence of the occurrence of this poison in human secretions.

Its ordinary properties are well known. It is very volatile.

The alkaline cyanides are soluble in water, and evolve hydrocyanic acid when treated with dilute acids.

The most important means of recognising this acid are as follow:—

1. Nitrate of silver causes a white precipitate in its solution and that of its soluble salts; this is unaffected by light and insoluble in cold nitric acid, both dilute and concentrated, but dissolved by either on ebullition. It is also soluble in ammonia.

2. When treated with solution of potash in excess, and a mixture of a proto- and persalt of iron added, a reddish-brown or greenish precipitate is formed; if muriatic acid be next added, prussian blue remains; the muriatic acid dissolves any protoxide or peroxide mixed with the latter, and disguising its characteristic colour.

It may be separated from a fluid by distillation in a water-bath, alcohol having been previously added. If the fluid contain an alkali, or alkali be formed during the distillation, a little sulphuric acid should be previously added. The distillate should then be neutralized with potash; the alcohol driven off by a gentle heat, and the residue tested as above.

25. FORMIC ACID has been supposed to occur in the urine. It is a colourless fluid, boils at  $210^{\circ}$ , is not precipitated by nitrate of silver and protonitrate of mercury, but its soluble salts are; if the solutions were concentrated, the solutions become black from the reduction of the silver and mercurial salts; this ensues immediately if they are heated. The precipitates are composed of the reduced metals. When a solution of perchloride of iron is added to one of formic acid or a formate, a blood-red colour is produced, as with acetates and sulphocyanic acid, or sulphocyanates. The reaction with nitrate of silver and chloride of iron would serve to distinguish this acid. Since under some circumstances the acetate of mercury is reduced by heat, and the acetates react with chloride of iron in the same manner as the formic acid or formates, the mercurial test should not be relied upon.

Formic acid is composed of  $C^2 H O^3, HO$ . Its atomic weight is 37.

26. BENZOIC ACID occurs in putrid urine, and may probably hereafter be shown occasionally to replace hippuric acid in the urine of man, as occurs in some animals.

It is but little soluble in cold water, more so in hot, and readily so in alcohol and æther. It sublimes readily by heat.

It consists of  $C^{14} H^5 O^3 + HO$ . Its atomic weight is 113.

Its crystalline form has been noticed in Part I. p. 42. See also Pl. IV. fig. 24.



27. OXALIC ACID has been found in the urine only (Part I. p. 43.)

It is soluble in water and alcohol, and effloresces in the air. When heated with sulphuric acid, it is decomposed, carbonic acid and oxide being evolved, but the mixture is not blackened. Its solution and that of its soluble salts are precipitated by solution of sulphate of lime; the precipitate is insoluble in acetic acid and muriate of ammonia, but soluble in nitric and oxalic acids.

It is composed of  $C^2 O^3 + 3HO$ . Its atomic weight is 36.

Its crystals are either four-sided prisms, or rhombic plates.

28. OXALURIC ACID has never been found in animal fluids, but its occurrence in the urine is not improbable.

It forms a white crystalline powder, and is difficultly soluble in water. When its solution is boiled, it is resolved into oxalic acid and oxalate of urea.

It is composed of  $C^6 H^3 N^2 O^7 + HO$ . Its atomic weight is 123.

It may be obtained by treating a solution of uric acid in dilute nitric acid with excess of ammonia. Oxalurate of ammonia crystallizes on evaporation. This is then decomposed by a mineral acid.

29. TARTARIC ACID has been found in diabetic urine in combination with lime.

It is readily soluble in water, but with difficulty in alcohol. Its crystals are acute rhombic prisms.

It is composed of  $C^4 H^2 O^5$ ; its atomic weight is 66.

The bitartrate of potash is figured in Pl. IV. fig. 27, and the tartrate of lime in Pl. IV. fig. 22. The tartrate of lime is readily distinguished from the oxalate by its form.

## VI. INORGANIC MATTERS.

### 1. ACIDIFIABLE SUBSTANCES AND ACIDS.

30. SULPHUR occurs in minute quantity in the proteine compounds, gelatine, bile, &c.

Its properties are too well known to require description. To detect sulphur, the suspected substance or liquid should be boiled with a solution of oxide of lead in solution of potash; if blackening occur, sulphur is present. The most certain method of detecting sulphur is to wash away all soluble substances from the suspected matter, then to dry it and incinerate it with the addition of nitric acid, or what is better, a mixture of nitrate of potash and carbonate of barytes. The residue is exhausted with water and dilute nitric acid, the sulphate of baryta is left.

In insoluble organic compounds, the sulphur may be separated quantitatively by treating them with water and acetic acid; then digesting for some time with nitric acid, the sulphuric acid thus formed is then precipitated by baryta (29) and the amount of sulphur calculated. 100 parts of sulphate of baryta are = 13.797 sulphur.

31. **SULPHURIC ACID** is a common constituent of the ash of animal fluids. It may be formed by the oxidation of the sulphur existing in the liquid or solid, and thus be a product and not an educt, as in milk.

It is very readily detected by the precipitate caused in its solution by any soluble barytic salt; this precipitate is insoluble in all acids. The nitrate or the chloride is best used for this purpose, and the solution should be previously acidified with nitric acid (*vide* Part I. p. 29.)

32. **MURIATIC ACID** has long been supposed to occur in the stomach in the free state, and the question cannot yet be considered as decided. Combined with soda it is found abundantly in all animal fluids.

It is readily recognised and estimated by means of nitrate of silver (*vide* Part I. p. 29.) Care must be taken to distinguish the chloride of silver from the cyanide,\* with which it has been confounded. This may be avoided by recollecting that the cyanide is unaltered by light, whilst the chloride is blackened; they are both insoluble in cold dilute and concentrated nitric acid, but the cyanide is dissolved by the boiling concentrated and dilute acid. Both

\* This is undoubtedly sometimes formed by the incineration of animal matters, either containing much alkali, or to which such has been added.



are soluble in ammonia. In estimating the muriatic acid, the cautions given in Part I. p. 29 should also be attended to. 100 parts of chloride of silver are = 25.366 muriatic acid.

When free muriatic acid, muriate of ammonia, and fixed alkaline chlorides occur together, they may be thus estimated: divide the liquid into three parts, evaporate one to dryness and incinerate the extract, the ash dissolved in water and treated with nitrate of silver, &c. yields the amount of fixed chlorides, the muriatic acid and ammonia being volatilized; the second portion is very accurately neutralized with potash, evaporated, incinerated, and treated as above; the increase in the quantity of chlorine arises from the free muriatic acid; the third portion should be supersaturated with potash, evaporated and incinerated, &c. as before, the potassium in the excess of potash retains the chlorine in the acid combined with the ammonia. The second and third curdy precipitates should be boiled with dilute nitric acid to remove any cyanide formed, the chloride of silver not being dissolved by hot nitric acid.

33. PHOSPHORUS exists in most of the proteine compounds.

The amount of phosphorus in an organic substance may be ascertained by previously acting upon it with water and acetic acid. An accurately weighed portion of pure iron is then dissolved by heat in nitric acid (about 1 part of iron to 2 of acid) with the compound to be analyzed; the whole is then precipitated by ammonia.\* The precipitate is washed, dried, and heated to redness. By reducing from the weight obtained that of the oxide of iron corresponding to the iron used, we ascertain the weight of the acid. 100 parts of phosphoric acid are = 43.98 parts of phosphorus.

34. PHOSPHORIC ACID never occurs free in animal fluids. It is met with in three forms, as a monobasic, bibasic and tribasic acid. The latter occurs most frequently, but the bibasic is sometimes found. The monobasic is also called metaphosphoric, the bibasic pyrophosphoric, and the tribasic is the common acid. The latter is converted into the bibasic by a red heat. The tribasic acid when neutralized

\* If the precipitate be white, too little iron has been used.

by an alkali precipitates solution of silver yellow, the other acids white. By heating the tribasic acid with excess of alkali, it retains the property of yielding a yellow precipitate with silver after a red heat. The monobasic is composed of  $P^2 O^5$ ,  $HO$ ; the bibasic,  $P^2 O^5$ ,  $2HO$ ; the tribasic,  $P^2 O^5$ ,  $3HO$ . The phosphate of silver is soluble in nitric acid and ammonia. Phosphoric acid yields white precipitates with the chlorides of calcium and barium, and which are soluble in muriatic or nitric acids, but precipitated on saturating with ammonia; if however a large quantity of these reagents be used, a portion is retained in solution. It yields, when neutralized, a white precipitate with solution of sulphate of lime, which is soluble in excess of acetic acid, and thus distinguished from the oxalic acid, which gives a precipitate insoluble in acetic acid.

Phosphoric acid, when combined with alkalies, may be estimated,— $\alpha$ , either by the method given in Part I. p. 29;  $\beta$ , by treating the solution with a mixture of sulphate of magnesia, muriate of ammonia and free ammonia, washing with water containing ammonia, drying and incinerating. 100 parts of the pyrophosphate of magnesia left are = 63.36 phosphoric acid;  $\gamma$ , or the iron process alluded to under *phosphorus* (33) may be used.

$\delta$ . When combined with earths the following process may be adopted: the compound is dissolved in muriatic or nitric acid and precipitated by sulphuric acid in slight excess, two volumes of alcohol being added at the same time. The solution is filtered, and the precipitate washed with dilute alcohol, dried and weighed. The phosphoric acid may then be calculated from the loss, or, after the evaporation of the alcohol, by the process described above ( $\beta$ ).  $\epsilon$ . Or, the compound having been dissolved in muriatic acid (avoiding great excess,) solution of perchloride of iron is added and then excess of acetate of soda; if the solution is not red, the chloride is added *guttatim* until it becomes so. The mixture is then boiled for five minutes. If a reddish-brown precipitate does not fall and the solution become colourless, more acetate of soda must be added. The solution is filtered whilst hot, and the precipitate well-washed. It is then dissolved in muriatic acid, tartaric acid and then ammonia added, until the precipitate at first formed

is redissolved by excess of the ammonia. The phosphoric acid is then precipitated by the process described in (34 $\beta$ .) To ensure the removal of every trace of iron, the washed precipitate should finally be dissolved in muriatic acid and precipitated by ammonia.\*

35. CARBONIC ACID is found both free and combined in animal fluids. It may be recognised by being conducted into lime water; a white precipitate of carbonate of lime is then formed, which is soluble with effervescence in a dilute acid. When existing in any liquid in a free state, it is expelled by a gentle heat. It is readily absorbed by a solution of potash, and is best estimated by absorption with potash, or transmission through a solution of caustic baryta.

36. HYDROFLUORIC ACID occurs in the human bones and teeth in combination with lime, and may be readily detected by heating the pulverized bones with sulphuric acid in a platinum crucible, upon the top of which is placed a glass plate coated with wax, and on which some device has been drawn. The vaporized hydrofluoric acid corrodes the glass, leaving an indelible impression of the device.

It is quantitatively determined by mixing the substance to be analysed with pure silica in a small flask; concentrated sulphuric acid which has been boiled, is then added, and the flask is closed with a cork through which a tube drawn out to a fine point and filled with fused chloride of calcium is passed. Fluoride of silicium is evolved; 1.395 part of this indicates one part of fluorine; 100 parts of fluoride of silicium are = 71.68 of fluorine.

37. SILICIC ACID or silica is characterized as much by its negative as any other characters. It is insoluble in water, alcohol, and all acids except the hydrofluoric. When fused with potash and treated with water, a portion is dissolved; this is precipitated in a hydrated state on the addition of an acid.

When silica is fused before the blow-pipe with carbonate of soda, effervescence ensues, and a clear transparent glass is formed. In the analysis of animal fluids, the silica remains as an insoluble residue of the action of all the ordinary solvents and acids on the ash. It is unknown whether

\* Fresenius.

the remarkable phosphate of magnesia  $3\text{MgO}, 2\text{P}^2\text{O}^5$ , discovered by Dr. Gregory, occurs in the ash of animal fluids. It is as insoluble as sulphate of baryta, and might therefore be mistaken for silica without proper care.

## 2. BASES.

38. POTASH.— $\alpha$ . The presence of potash, which should always be ascertained\* in the ash, is recognised by the yellow precipitate caused on the addition of solution of chloride of platinum. Its aqueous solution is also precipitated by tartaric acid in excess, carbazotic and perchloric acid.

$\beta$ . As potash is usually accompanied by soda in excess, the process for separating potash described here applies principally to its separation from that alkali. The ash is evaporated with slight excess of hydrochloric acid, heated to low redness, dissolved in water, treated with excess of aqueous solution of chloride of platinum, evaporated in the water bath nearly to dryness, alcohol of  $\cdot 896$  spec. grav. is then added, and after some hours' repose, the undissolved platino-chloride of potassium is separated by filtration, washed with alcohol and dried at  $212^\circ$  until it ceases to lose weight;† or the following modification may be used: instead of adding aqueous solution of chloride of platinum,  $3\frac{3}{4}$  times the weight of the ash of platino-chloride of sodium may be added; the mixture, dissolved in a little water, and evaporated to dryness at a gentle heat, is then treated with spirit ( $\cdot 896$ ), which dissolves chloride of sodium, and any excess of platino-chloride of sodium. The platino-chloride of potassium is then treated as above.

39. SODA.—The best method of detecting soda has been described in Part I. p. 30. Its quantitative analysis is sometimes performed negatively, by deducting the weight of the chloride of potassium from that of the mixed chlorides of sodium and potassium; the difference gives the chloride of sodium.

\* Vide Part I. p. 30.

† This should be effected on a filter which has been previously dried at a temperature of  $212^\circ$  until it ceases to lose weight; if the liquid be filtered through this, the precipitate is retained, and the increase in weight of the filter containing the precipitate is equal the weight of the latter.

40. AMMONIA does not exist in animal fluids in any considerable quantity, but occurs in small quantity combined with muriatic and perhaps phosphoric acids. It is copiously evolved from animal matters during decomposition. Its salts are volatilized at a heat below that of redness; when heated with potash, the ammonia is evolved; this is recognised as described in Part I. p. 33.

To estimate ammonia quantitatively, the following processes may be used:—

1st. The substance containing it, either fluid or solid, is distilled with excess of solution of potash by means of a retort and quilled receiver, the quill of the latter dipping into diluted muriatic acid. When rather more than half the solution has passed over and the whole of the ammonia has been evolved, the muriatic solution is treated with excess of chloride of platinum, &c., as directed under potash, (38. β.) The platino-chloride of ammonium thus obtained contains 7.63 per cent. of ammonia,  $(\text{NH}^3) = 8.08 (\text{NH}^4.)$

2d. The dried substance is heated, either alone or with hydrate of potash or oxide of lead, in a small tube which is sealed at one extremity. The empty tube thus sealed is first weighed; the salt is then put into it and the whole again weighed; if alkali be used a third weighing must be made after its addition; the open extremity is then drawn out to a fine orifice, which is inserted into a cork which closes one extremity of an equal-sized tube containing hydrate of potash or caustic lime; the other end of the potash tube is furnished with a cork, through the centre of which a small piece of glass tube is passed, or it is drawn out. The whole apparatus is weighed, either joined or separately. Heat is then applied to the tube containing the substance, commencing at the extremity nearest to the potash tube (which should be curved at an obtuse angle;) when this portion is heated the lamp should be gradually applied to the remainder of the tube until every trace of ammonia is expelled, which may be known by the application of turmeric or dahlia-paper to the open extremity of the potash tube. When this is the case, and the apparatus is cold, it is again weighed; the ammonia has escaped, the potash has retained the water; consequently the loss is = the ammonia. Or, another tube, filled with sulphate or



chloride of copper, may be attached to the free end of the potash tube ; this will absorb the ammonia, the amount of which can then be directly ascertained.

41. LIME, if previously to incineration combined with an organic acid, is found as carbonate in the ash. In the soluble salts it is recognised by solution of oxalate of ammonia causing a precipitate in the neutral solution ; and estimated quantitatively, by adding slight excess of ammonia, and then excess of oxalate of ammonia, setting the mixture aside at a gentle heat, filtration and incineration. The ash thus obtained is moistened with solution of carbonate of ammonia, and again heated to low redness ; or treated with dilute sulphuric acid, evaporated and maintained at a red heat until the excess of sulphuric acid is expelled, then weighed as sulphate.

In an insoluble compound, the process described in Part I. p. 30, may be used. It is more easily and accurately accomplished in modifying this process, by adding slight excess of ammonia, then a drop of muriatic or acetic acid, and subsequently excess of oxalate of ammonia, and proceeding as above. Oxalate of lime is insoluble in ammonia, very slightly soluble in oxalic and acetic acid, and readily so in the mineral acids. The microscopic form will assist in its detection (Part I. p. 43.)

42. MAGNESIA, like lime, nearly always occurs as a phosphate. Solutions of magnesia are precipitated by ammonia unless muriate of ammonia be present, when this is not the case ; oxalic acid and oxalates cause no precipitate in a magnesian solution. The problem most frequently occurring is the separation of the phosphate of magnesia from that of lime ; this has been solved in Part I. p. 30. The ammonio-phosphate of magnesia is but little soluble in a weak solution of ammonia ; this should therefore be used to wash the precipitate.

Another method of separating the lime from the magnesia in the phosphates is by thoroughly fusing them with excess of carbonate of soda, or a mixture of the carbonates of soda and potash. The mass is to be treated with water, and the earthy carbonates dissolved in excess of dilute muriatic acid, slight excess of ammonia is to be added ; if any precipitate be formed, more acid must be added, and this again

treated with slight excess of ammonia. The lime is precipitated by excess of oxalate of ammonia, warmed and filtered; the filtrate is treated with a mixture of ammonia and phosphate of soda, the precipitate allowed to subside, and well-washed with a weak solution of ammonia.

When magnesia is heated before the blowpipe on charcoal, then moistened with solution of nitrate of cobalt and again heated, it becomes pale red or flesh coloured.

43. ALUMINA never occurs in the healthy fluids, but has been found in bones and teeth, and in the fæces after the internal use of alum.

Alumina which has been heated to redness is soluble in acids with difficulty, but soluble in excess of solution of potash.

The hydrate is insoluble in water, readily soluble in potash, soda and acids, with difficulty in ammonia, and insoluble in carbonate of ammonia. It is precipitated by ammonia or its carbonate from the soluble salts.

When treated before the blowpipe, as directed for magnesia (40,) it acquires a bright blue colour.

It may be separated from the phosphates with which it remains mixed in the ash,—1st, by fusion with carbonate of soda or potash, exhausting the mass with water, which dissolves out the alumina, alkali and phosphoric acid, leaving the magnesia and lime; the alumina is then precipitated by supersaturating the filtrate with muriatic acid and the addition of caustic ammonia; 2d, by digestion with caustic soda, in which it dissolves; 3d, or by fusion with bisulphate of potash, digestion with water, and precipitation by ammonia. The precipitate should then be dissolved in muriatic acid, and again precipitated by ammonia.

44. OXIDE OF IRON is a very common ingredient of most secretions, but is generally in small quantity only. It gives the ash a reddish-brown colour. It is detected by digesting the ash in dilute muriatic acid, nearly neutralizing by ammonia, and then adding ferrocyanide of potassium, which causes a blue precipitate if iron be present. Sulphocyanide of potassium and tincture of galls may also be used as tests; with the former the solution must not be alkaline, and with the latter it should be neutral.

Iron may be separated quantitatively, when not mixed



with the phosphates, by precipitation with ammonia; it then falls as peroxide, which must be washed and heated to redness. When mixed with the phosphates, the ash should be fused with carbonate of soda, the mass exhausted with water, the undissolved residue dissolved in excess of muriatic acid, ammonia then added to precipitate the iron, the liquid filtered, the lime separated by oxalate of ammonia, and the magnesia by treating the filtrate with ammonia and phosphate of soda, as in 42.

Or, after fusion with carbonate of soda, and the addition of muriatic acid, and nearly neutralizing with ammonia, the iron may be precipitated by hydrosulphuret of ammonia. When this has ceased to yield a precipitate, the liquid should be gently heated, set aside and filtered; the filter and washed sulphuret are then digested with nitric acid at a gentle heat, filtered to separate any undissolved sulphur, and the peroxide of iron precipitated by ammonia.

Iron may also be detected by the ash becoming magnetic when heated before the blowpipe on charcoal; producing with borax a reddish glass, which becomes yellowish or colourless on cooling in the outer flame, and a bottle- or bluish-green glass in the inner flame.

The remaining metals require but a very short notice, as they occur in extremely minute quantities, if at all, in the healthy body, although they frequently exist in the fluids after their exhibition medicinally, or as poisons.

45. OXIDE OF MANGANESE.—This has been found in the air and in biliary and vesical calculi.

It is most readily detected by the blowpipe. When heated on platinum-foil with soda, it forms a green glass, which when cold becomes bluish-green. With borax it forms a clear amethystine glass; the colour is destroyed in the reducing flame.

In the moist way, a very delicate test is the action of peroxide of lead and dilute nitric acid at a gentle heat; the liquid becomes of a fine purplish-red colour.

46. OXIDES OF COPPER AND LEAD are stated to have been detected in, and to exist as natural components of the soft parts and blood of the human body. They have been obtained from the intestines by completely incinerating the

well-dried animal matters, dissolving that portion of the ash insoluble in water in muriatic acid, and precipitating the metal by sulphuretted hydrogen; the precipitated sulphuret was dissolved in nitromuriatic acid, sulphuric acid added, and the solution evaporated without filtration. On treating the residue with water, sulphate of copper was removed and sulphate of lead left.

Lead has been detected by deflagrating the matters with nitre, treating the residue with nitric acid, filtering and neutralizing the solution, then testing it with sulphuretted hydrogen, carbonate of potash and iodide of potassium; also copper, by incinerating the substance and treating with nitric acid as above. The neutralized solutions gave indications of it with sulphuretted hydrogen, ammonia and ferrocyanide of potassium.

Titanic acid has been stated to exist in the blood and renal capsules. I have examined the ash of blood very carefully, both in its ordinary state and after exhaustion with water and muriatic acid. In the former case, the reactions of iron were of course evident, but no purplish tinge could be produced with salt of phosphorus in the inner blowpipe flame on cooling, although this, which is the best test for titanic acid or titanium, readily occurred on adding a little titanic acid.

In the latter case the ash is not entirely deprived of its colour; this arises from the presence of a little silicate of iron, left undissolved by the acid, which also gives the blowpipe reactions of iron, but no trace of titanic acid could be detected.

47. SALTS.—The various salts occurring in animal fluids and solids will be mentioned in the analyses of the various compounds in which they occur. A few of their characters, which are important in analysis and facilitate their recognition and separation, will be described here:—

1. *Phosphates of Lime*.—Two of these salts are sometimes met with, a neutral and a basic.

*The neutral* ( $2\text{CaO}, \text{P}^2\text{O}^5$ ) has only been found in calculi. When heated it fuses with difficulty. It consists of 55.62 acid and 44.38 base.

*The basic* ( $8\text{CaO}, 3\text{P}^2\text{O}^5$ ).—This salt is very generally

diffused through the fluids of the body, and exists abundantly in the bones. It may be raised to a white heat without fusing.

Berzelius has shown that the phosphate of lime obtained by treating a solution of bone-ash in muriatic acid with ammonia is not always the same. Thus the first precipitate is  $8\text{CaO}, 3\text{P}^2\text{O}^5$ ; but towards the end of the precipitation the true basic phosphate of lime,  $3\text{CaO}, \text{P}^2\text{O}^5$ , is formed; so that the precipitate may consist of both. The first gives 48·5 per cent. of phosphoric acid, the basic 45·95 per cent. of acid. The compound  $8\text{CaO}, 3\text{P}^2\text{O}^5$  is probably therefore  $2(3\text{CaO}, \text{P}^2\text{O}^5) + 2\text{CaO}, \text{P}^2\text{O}^5$ , *i. e.* a double salt consisting of 1 atom of the neutral with 2 of the basic phosphate. They are both usually amorphous, but the latter is sometimes found in the crystalline form (Part I. Pl. I. fig. 18\*; Part II. Pl. IV. fig. 29.)

2. *Phosphates of Magnesia.*—These are three. Two have been described in Part I. p. 34; a third occurs in the bones, some calculi, &c. The composition of these phosphates, quoted from Vigla in Part I. p. 34, is incorrect. The prismatic or neutral salt has probably the same composition as regards the phosphoric acid and magnesia as the basic salt, but perhaps contains less ammonia; when dissolved in a dilute acid and precipitated by ammonia, it subsides in the basic form, and is analogous to it in composition. It has never been analyzed, therefore its composition is uncertain.

I analyzed the bibasic compound, and found that it corresponded with the phosphate artificially prepared by Graham. It was prepared by precipitating the lime from filtered urine by oxalate of ammonia, filtering and adding pure ammonia; it was subsequently dissolved in dilute muriatic acid and re-precipitated by ammonia.

After drying in the air, it lost 54·92 per cent. of water and ammonia at a red heat. The residue yielded,—phosphoric acid, 63·903; magnesia, 36·097 per cent. The ammonia amounted to 6·588.  $= \text{NH}^1\text{O}, 2\text{MgO}, \text{P}^2\text{O}^5 + 13\text{HO}$ .

The third phosphate, found in bones, &c., is composed

of  $3\text{MgO}$ ,  $\text{P}^2\text{O}^5$ . It is probably amorphous. It fuses to a clear glass, and gives 54·34 per cent. of phosphoric acid.

The remaining salts worthy of notice are arranged in the following table:—

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*Notes to the Table.*

\* The only instance in which carbonate of lime has been found in a crystalline state in any human secretion occurred to myself. I found it in the urine (Med. Gaz., vol. xxxiii. p. 829.) It is represented in Plate III. fig. 12.

† 100 parts of chloride of sodium are = 25·36 of muriatic acid.

‡ 100 parts of chloride of silver are = 40·88 of chloride of sodium.

Salt.	Solubility in water.	Solubility in alcohol.	Percentage of base.	Microscopic form.
Acetate of baryta . . . .	Soluble .	Soluble . .	60.01	Amorphous.* Amorphous.  Acute rhombic prisms. Plate I. fig. 28. Sometimes octahedra, but generally peculiar foliaceous forms (Plate III. fig. 9.) Cubes, much resembling chloride of sodium, but more frequently combined into peculiar staff-like bodies, the margins of which exhibit portions of the square outlines. Minute octahedra.
Carbonate of lime . . . .	Insoluble .	Insoluble .	56.29	
Carbonate of magnesia . . . .	Insoluble .	Insoluble .	48.31	
Carbonate of potash . . . .	Very soluble	Insoluble .	68.09	
Carbonate of soda . . . .	Very soluble	Insoluble .	58.58	
Chloride of sodium . . . .	Very soluble	Sol. when dilute	Part I. p. 26.†	Same as platino-chloride of potassium.  Amorphous. (At 212°.) Plate II. fig. 26. Frequently amorphous when precip. hot.  Membranous and fibrous-looking flakes. Excessively minute 6-sided prisms, with dihedral summits. 4 sided pr., with dihedral summits.
Chloride of ammonium . . . .	Very soluble	Soluble . .	31.83(NH <sup>3</sup> )	
Chloride of potassium . . . .	Very soluble	Sol. when dilute	52.45	
Platino-chloride of potassium	But little sol.	Insoluble .	19.334 (KO)	
Platino-chloride of sodium .	Soluble .	Soluble.	8.08(NH <sup>4</sup> )	
Platino-chloride of ammonium	Slightly sol.	Insoluble .	Part I. p. 26.†	Amorphous. (At 212°.) Plate II. fig. 26. Frequently amorphous when precip. hot.  Membranous and fibrous-looking flakes. Excessively minute 6-sided prisms, with dihedral summits. 4 sided pr., with dihedral summits.
Chloride of silver . . . .	Insoluble .	Insoluble .	80.58 (Ag)	
Cyanuret of silver . . . .	Insoluble .	Insoluble .	38.36	
Oxalate of lime . . . .	Insoluble .	Insoluble .	36.64	
Phosphate of magnesia, (pyrophosphate) . . . .	Almost insol.	Insoluble .	42.78	
Phosphate of iron (basic) . .	Insoluble .	Insoluble .	41.18	
Sulphate of lime . . . .	Rather insol.	Insoluble .	34.01	
Sulphate of magnesia . . . .	Soluble .	Insoluble .		

Having detailed the most important characters of those substances which enter into the composition of the animal fluids, it might be expected that it would be an easy task at once to distinguish any one from the others. This will not always be found the case. The inorganic substances are readily recognised; not so, however, the organic. In many instances ultimate analysis will alone decide the question; this, in many cases, may be avoided, and the object attained by the estimation of the atomic weight of the substance, the method of accomplishing which I shall briefly describe. The substance must be purified as completely as possible, if crystalline, by recrystallization. It is then combined with some fixed base. Oxide of lead or silver is generally used for this purpose, because most of their salts are insoluble and anhydrous, and moreover the quantity of the base is susceptible of accurate determination. Supposing then that the substance, as free as possible from other organic matters, has yielded a crystalline or insoluble salt with either of these bases (and for this purpose the substance should be first dissolved in some alkali, and then decomposed by a soluble salt of lead or silver, or precipitated at once by the addition of a soluble salt of lead or silver to its solution.) The quantity of water combined with it is first ascertained by heating it to the highest temperature possible without effecting its decomposition. In most cases  $212^{\circ}$  is sufficient; in a few  $390^{\circ}$  may be required. The loss is estimated as the water. The amount of base is next sought. If the substance be volatile by heat, and it is combined with lead, the mixture should be treated with sulphuric acid in excess, then heated, at first gently, finally at a continued red heat, until the whole of the free sulphuric acid is volatilized. When combined with the silver, it is best at once heated to redness. When the substance is not volatile, the compound should be heated to redness without any addition. It sometimes happens that a portion of the lead is reduced to the metallic state, or the silver is converted into carburet. In either of these cases\* the residue is treated with nitric acid, and then again heated as before. The

\* The oxide of lead may be separated from the metallic lead by acetic acid.



amount of oxide of lead is then ascertained, in the first case from that of the sulphate; in the second, the residue is pure oxide. The oxide of silver is calculated from the metallic silver. Having thus ascertained the proportions of the electro-negative body and of the base, the atomic weight of the former is at once found by the following proportion:—The amount of base is to the amount of the electro-negative body as the atomic weight of the base is to that of the electro-negative body. Thus, on distilling putrid urine with sulphuric acid, we observe the deposition of a crystalline sublimate on the neck of the retort; this, when carefully removed, accurately neutralized with ammonia, decomposed with nitrate of silver, washed and dried, yields 47·22 per cent. of metallic silver = 50·71 oxide of silver. Then

$$50\cdot71 : 49\cdot29 :: 116\cdot3 : x.$$

$$\log : 4929 = 3\cdot69276$$

$$\log : 1163 = 3\cdot06558$$

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$$= 6\cdot75834$$

$$\log : 5071 = 3\cdot70509$$

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$$= 3\cdot05325 = 113\cdot0^*$$

By referring to the atomic weights of the substances, we find at once that this was benzoic acid.

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## VII. THE BLOOD.

48. The study of the chemistry of the blood, which is certainly more important than that of any other fluid, is at the

\* These logarithms are not used for the purpose of unnecessary parade, but with a view of bringing them prominently before the student, who will find them invaluable in abridging the sums which are constantly arising in analysis. The comparison of the present with the ordinary method renders this at once evident; and it must be remembered that more than half the figures here used are unnecessary, except to render it clear to those unacquainted with the process.



same time considerably more difficult. We are but imperfectly acquainted with several of its constituents; the processes for its analysis must therefore be imperfect.

The blood is viscid, of higher specific gravity than that of any other animal fluid, and slightly alkaline. The specific gravity has been very differently estimated by various observers; this however most probably depends upon its varying in different individuals; 1050 may be considered as an average. Its odour, which is most perceptible in that recently drawn, is peculiar, and is said by M. Barruel closely to resemble that of the perspiration, and to be so characteristic that the species and even the sex of the animal from which it has been drawn may be determined by it;\* it is stronger in the blood of males than in that of females.

Its colour is different, according to whether it is removed from a vein or an artery. These differences are well known. The colour depends upon a peculiar substance contained within the corpuscles in a fluid state, and called hæmatine; its properties will be described presently.

Whilst circulating in the vessels, it is composed of a liquid, the *Liquor sanguinis*, and corpuscles, which are suspended in the former; the diffusion of the latter in great numbers throughout the mass, gives to the blood its uniform colour.

When allowed to repose after removal from the vessels, it coagulates, forming a coloured clot, or crassamentum, and a fluid portion, which contains a few corpuscles suspended towards the lower part of the vessel, the serum. The clot is not equally red; the upper part is usually of a lighter and brighter colour than the lower, which is very dark, appearing almost black. If, immediately after being drawn, it is stirred with a glass rod, or shaken in a bottle with a loose body of any kind, the coagulum adheres to the body, contains much fewer corpuscles, and is of a much brighter colour than in the former case. Under these circumstances the coagulum consists of fibrine containing but few corpuscles, whilst the fluid part or cruor consists of the

\* The evolution of this odour when dried blood is treated with sulphuric acid has been proposed as a medico-legal test; it is however of little value.

serum, containing most of the corpuscles in suspension. The coagulation probably commences immediately the blood has left the vessels; but little alteration can be perceived with the naked eye until from 2 to 3 minutes, when the surface assumes a greenish tinge; the whole mass then becomes gelatinous, progressive separation takes place, and at the end of 20 or 30 minutes the process is completed. It commences sooner, and is sooner completed, in arterial than in venous blood. The caustic alkalies and some salts prevent or delay the coagulation of the blood, especially sulphate of soda, nitrate and acetate of potash, &c. The coagulation is caused by the fibrine alone; the globules have no essential share in the process.

*Microscop. char.*—The microscopic peculiarities of the blood are its globules. These are of two distinct kinds; the first is composed of very numerous small circular flattened discs, of a yellowish colour, their margins being obtusely rounded, their centres equally depressed on either side; they are about the  $\frac{1}{3500}$ th of an inch in diameter, and  $\frac{1}{4}$ th or  $\frac{1}{2}$ th of this in thickness at the circumference, but much thinner in the depressed centre; this is the average, but they are not uniform, although from their minute size and large number they appear so, unless very highly magnified. They are cells, composed of a highly elastic colourless membrane, which is filled with a coloured fluid. That such is their constitution may be proved by an examination of the phenomena of exosmosis and endosmosis, which they exhibit when mixed with fluids of greater or less density than that which they contain; thus, concentrated saline solutions contract and wrinkle them, whilst they imbibe solutions of low specific gravity, becoming exceedingly distended. When acted upon by water, they become pale or colourless, the colouring matter being dissolved; they finally disappear, some being completely dissolved, others so distended that their walls become too transparent to be perceptible. On the addition of strong saline solutions, solution of iodine, &c., the globules are again partly rendered visible.\* When treated with acetic acid, they

\* The action of water upon the red corpuscles is not uniform; some of them are entirely dissolved, others merely distended, and a few are scarcely at all affected; the latter are generally the smallest.

leave no nuclei. It is stated, that when treated with water and set aside, the corpuscles are dissolved and the nuclei precipitated, forming the whitish deposit which forms under these circumstances. This deposit however principally consists of albumen precipitated from the serous fluid contained within the corpuscles; it also contains some colourless and red corpuscles, which have remained unacted upon. The second kind, called lymph-globules, is composed of spherical corpuscles; these are about one-fourth larger than the former, and fewer in number, being in the proportion of 1 to 5.\* They are white, highly refractive, granular on the surface, and specifically lighter than the red corpuscles, and are stated to contain moving molecules in their interior. When acted upon by acetic acid, they are dissolved with the exception of the nuclei, which vary in number, but are generally 2 or 3.

In addition to these bodies, the proper corpuscles of the blood, that fluid also contains, under certain circumstances, globules of oil, the molecular base of the chyle, and another molecular substance exactly similar to the latter in appearance, but differing in chemical properties; and lastly, the minute irregular granules found in all animal fluids.

Those proximate principles which are common to several animal fluids have been already treated of. As we arrive at the consideration of the compound fluids themselves, such substances as are peculiar to them will be described.

49. **FIBRINE** is noticed at page 64. When treated with alcohol or æther, it yields a yellowish-brown acid mass, which is crystalline when cold, and is soluble in cold alcohol; when incinerated, it leaves an alkaline ash, resulting from the decomposition of the acid soap. The quantity yielded by dried fibrine is from 2 to 5 per cent.

50. **GLOBULINE** is described at p. 64. It is uncertain whether the walls of the corpuscles are composed of this substance, or whether it exists in the fluid portion only; the latter is most probable, the corpuscular walls being constituted of albumen.

This probably depends upon their different stages of development, and a varying thickness of their walls.

\* Wagner. This estimate is certainly too high.

51. HÆMATINE is the substance to which the colour of the blood is owing:—

α. It exists in two states. We are unable to judge of the properties of its solution as existing in the blood, because it cannot be separated from the albuminous ingredient with which it is mixed. When dried, it forms a dark, reddish-brown shining mass, insoluble in water, alcohol and æther. It is dissolved by water containing potash; dilute mineral and acetic acids cause brown precipitates in this solution, which is also precipitated by bichloride of mercury, both acetates of lead, protochloride of tin, nitrate of silver, alum and tannic acid. Ferrocyanide of potassium causes a precipitate in its acid solution. By digestion with dilute sulphuric acid, it is not dissolved, but a part of its iron removed, and its properties become so altered that it is soluble in alcohol and æther.\* Hæmatine forms compounds with mineral acids, which are insoluble in water but soluble in alcohol. When triturated with sulphate of soda and alcohol is added, a portion becomes dissolved. When incinerated, it leaves a reddish ash, consisting of oxide of iron (about 10 per cent.,) but neither any earthy matter, alkali, sulphur nor phosphorus.

It is composed of  $C^{44} H^{22} N^3 O^6 Fe$ , giving per cent.,—carbon, 66·49; hydrogen, 5·30; nitrogen, 10·50; oxygen, 11·01; and iron, 6·66.

β. Thus, although it resembles the proteine compounds in so many of its properties, it cannot be referred to them.

When chlorine is passed through hæmatine suspended in water, the colour is destroyed, white flakes are deposited, and the solution contains iron; the flakes are composed of  $C^{44} H^{22} N^3 O^{24} + Cl^6 = Hä + ClO^3$ .

The condition of the iron in the hæmatine and its relations to the red colour are still obscure, as is the nature of the hæmatine itself. The iron most probably exists in the metallic state, as it has been shown that by digesting pure hæmatine containing iron with strong sulphuric acid, and subsequent dilution and washing with water, hydrogen is disengaged, and the whole of the iron may be removed, the hæmatine retaining its atomic constitution, colour and gene-

\* Lehmann.

ral properties. This shows that the iron and colour are quite independent of each other. We shall return to some properties of hæmatine in the consideration of the chemistry of the corpuscles.

γ. Hæmatine may be obtained (α.) by mixing blood, from which the fibrine has been removed by stirring, with a saturated solution of sulphate of soda; the mixture is filtered, and the insoluble corpuscles are boiled with alcohol acidulated with sulphuric acid until the albumen (globuline) remains as a grayish mass. The solutions must be filtered whilst hot, then treated with carbonate of ammonia; this precipitates the albumen (globuline) and the acid; the red filtered fluid is then evaporated to one-twelfth of its volume; the hæmatine subsides as a dark powder, which contains a little fat; after separating this by æther, the hæmatine is pure.

52. SEROLINE is a fatty matter peculiar to the blood. It forms pearly scales, which fuse at  $96^{\circ} \cdot 8$  F.

*Chem. prop.*—It is nearly insoluble in alcohol (0·833) when cold, more so when hot, being again deposited as the solution cools; it is readily soluble in æther; not saponified by alkalies in solution; is neutral, and evolves ammonia when heated, and is reddened by sulphuric acid like cholesterine. It may be obtained by evaporating the blood to dryness, exhausting the residue with boiling water, again drying, exhausting the residue with boiling alcohol) and filtering whilst hot. On cooling, the seroline is deposited; it must then be washed with cold alcohol.

*Microscop. char.*—It appears to exist in two forms, one amorphous, the other\* composed of filaments, upon which small tubercles or nodes are situated.

53. FAT CONTAINING PHOSPHORUS.—If dried and powdered blood be exhausted with water, again dried and powdered, and then exhausted with boiling alcohol, the filtered solution on cooling deposits seroline. The solution filtered from this leaves on evaporation a mixture of several fats; cold alcohol (0·883) removes all but the phosphorized fat. But little is known regarding this fat; it seems to resemble Fremy's cerebrie acid. The colour of the red phos-

\* Boudet.



phorized fat is due to hæmatine; it is probably merely an admixture of other fats.

54. CORPUSCLES.—The compound of albumen (globuline) and hæmatosine, forming the contents of the corpuscles, cannot be perfectly separated from the other constituents of the blood. The corpuscles themselves are most perfectly separated by mixing the beaten blood (48) with from 5 to 8 vols. of a saturated solution of sulphate of soda; the mixture is set aside, then poured upon a filter. The greater part of the blood-corpuscles remains on the filter, not unaltered, however, for they have lost their primitive form, and become irregular, wrinkled and meniscoidal. It is perhaps better to wash the serum as much as possible from the corpuscles by sulphate of soda and decantation. As soon as the sulphatic solution ceases to dissolve any more albumen, filter, and treat the red magna with water; the contents of the globules then become dissolved in the water, which now again gives all the ordinary reactions of albumen (globuline?). In addition to albumen, they also contain carbonate of soda, oxide of iron and earthy phosphates. When their aqueous solution is allowed to repose, a deposit of albumen occurs, just as is the case with all albuminous solutions when diluted; this deposit is not so copious in the solution of corpuscles which have been treated with the sulphate, as it is partly retained in solution by it. This fact also assists us in forming the conclusion, that this deposit does not consist of nuclei nor membranes of the corpuscles, as the latter are insoluble in sulphate of soda.

The aqueous solution of the corpuscles is coagulated by heat, the coagulum assuming a dark reddish brown, and the liquid a pale yellowish colour. It is also precipitated by alcohol, mineral acids, bichloride of mercury, tannic acid, both acetates of lead and electricity. These reactions are important, especially that with heat, as being the best means of recognising blood in the secretions when the globules cannot be detected with the microscope.

When the aqueous solution of the corpuscles is dried, a reddish-black coagulum forms. This is insoluble in water, soluble in potash, also in spirit (0.91) by ebullition, again subsiding as the solution cools. The dried corpuscles contain about 5.5 per cent. of hæmatine. Berzelius obtained

1·3 per cent. of ash from them, consisting of carbonate of soda with traces of phosphate, 0·3;\* phosphate of lime, 0·1; caustic lime, 0·2; basic phosphate of iron, 0·1; oxide of iron, 0·5; carbonic acid and loss, 0·1.

One of the products of the decomposition of hæmatine, or this substance altered in its properties by the action of reagents, has been called hæmapheine by Simon. It is probably the same substance as that described by Sanson, but no analysis has yet been made of it, so that we are not acquainted with its relation to hæmatine. It seems under certain circumstances to be very readily formed from the latter. It does not occur in the undecomposed blood, but when, from disease, the plasticity of this fluid is diminished, it is readily formed from the hæmatine. It is always formed when the dried corpuscles are boiled with alcohol acidulated with sulphuric acid. It is distinguished from the hæmatine by its solubility in alcohol and æther even when cold; also in water. It leaves a very minute amount of ash, which contains but a trace of oxide of iron. It is not improbable that this substance is hæmatine without the iron.

55. SERUM.—The serum is of a pale yellow colour with a tinge of green. Its specific gravity is about 1·030; it is slightly alkaline, and gives all the ordinary reactions of albuminous fluids. When evaporated to dryness and incinerated, it leaves an alkaline ash amounting to about 1 per cent., and containing carbonate, sulphate and phosphate of soda, chloride of sodium, with phosphate of lime and magnesia.

When copiously diluted with water, a precipitate of albumen subsides; this does not however occur if it be diluted with a saline solution; and if the alkalinity of serum be destroyed by an acid, and the mixture allowed to repose, at the end of some hours it becomes gelatinous from the separation of the albumen. The alkalinity of the blood in all probability depends upon the presence of carbonate of soda; some of the alkali is also combined with animal matter.† The Giessen school denies the existence of alkaline car-

\* A portion of this phosphate is probably formed by the union of the phosphoric acid in the phosphorized fat with soda.

† See Med. Gaz., vol. xxxvi. p. 186.



bonates in the blood, and asserts that the alkalinity depends upon the presence of tribasic phosphate of soda. In addition to the objections which I have elsewhere made to this view, it appears impossible for free carbonic acid and the tribasic phosphate to exist in this fluid without the latter being decomposed and carbonate of soda being formed, and the presence of carbonic acid in blood has been proved beyond a doubt.

Ludwig has recently shown that the so-called extractives of the blood consist of binoxide of proteine, part of which is soluble in alcohol, the remainder being insoluble. He separates it by heating fresh, beaten and strained blood in an earthenware vessel over an open fire, constantly stirring it; as soon as the mass has acquired a brownish-red colour throughout, it is pressed between the folds of a linen cloth. The red alkaline fluid is then exactly neutralized with very dilute muriatic acid, rapidly heated to ebullition and filtered. It is then treated with 4-5 volumes of alcohol (0.848,) the mixture set aside; the flakes which subside by repose may be purified by decantation with alcohol, æther and water. Mulder states that metallic salts precipitate tritoxide of proteine from the serum of blood, after the albumen has been removed.

The microscopic appearance of coagulating blood is as follows:—If a drop from a healthy subject be placed under the microscope and immediately examined, the corpuscles are seen irregularly diffused over the surface of the glass;\* and if the latter be held between the light and the unarmèd eye, the blood appears as a uniform red spot; at the end of about one minute, the red corpuscles under the microscope are seen to unite by their flat surfaces, forming fibres (which much resemble strings of figs;) these interlace, leaving intermediate spaces;† if the glass be held up to the naked eye at this moment, the uniform appearance is exchanged for that of a very minute net-work, or alternation of dark red and light spots. After a time the fibres become broken up, and the corpuscles float loosely in the fluid. Within the meshes of the red corpuscles, the white or lymph-globules are distinctly seen floating separately. The solidi-

\* Pl. IV. fig. 16.

† Pl. IV. fig. 15.

fied fibrine is also seen in various parts of the field, some in a granular form, some in the form of very delicate fibres; these, in some cases, appear to be partly situated within the colourless corpuscles.

We now arrive at the consideration of a most difficult question, viz. the cause why the blood sometimes assumes a bright (arterial) and at others a dark (venous) colour. This has been long supposed to arise from the influence of the oxygen of the air, or the agency of saline matters. The following seem to be the most important facts relating to this point:—1st, when blood is exposed to air, or oxygen gas is passed through it, it assumes a bright arterial colour; 2d, when agitated with hydrogen or carbonic acid, or these gases are passed through, it is rendered almost black; 3d, when mixed with saline solutions or syrup, it assumes a bright colour, but not that of arterial blood; 4th, white insoluble powders, as chalk or carbonate of magnesia, also render it bright; 5th, after treatment with a saline solution, carbonic acid blackens and oxygen brightens it; 6th, there is no difference in the form of the corpuscles of arterial and venous blood at all comparable, if any, to that produced by saline solutions in those of venous blood; 7th, neither blood which has been mixed with water, nor that which has not, exhibits any perceptible difference in the form of its corpuscles after treatment with carbonic acid and oxygen;\* 8th, hydrogen removes carbonic acid from the blood; 9th, blood which has been darkened by either hydrogen or carbonic acid is reddened by oxygen; 10th, bright blood, on dilution with water, yields a bright solution, dark blood a dark solution.

It thus appears that the alteration in the colour of the blood may be produced by totally distinct causes. Although saline solutions brighten venous blood, the amount of saline matter not being greater in arterial blood than in the former, the effect cannot depend upon this cause; nor can it be connected with the alteration in the form of the corpuscles, as seen from 6 and 7. No particles which could possibly act in the manner alluded to in 4, are present in arterial blood. It cannot depend upon the mere removal

\* Bruch, Marchand.

of the carbonic acid, which darkens it, as seen from 8 and 2. Recent experiments tend to show that the gases in blood are not in a state of chemical combination, but merely in solution; the carbonic acid may however be in chemical combination with carbonate of soda in the form of bicarbonate, as the condition of the second atom of carbonic acid in the latter is similar to that of the carbonic acid in the blood. The oxygen appears to be the essential agent in producing the bright arterial colour, but the manner in which it accomplishes this is unknown. It is highly probable that the saline matters have no share in the phenomenon. That the influence of oxygen is much more potent is seen from 4. Blood which contains much carbonic acid has turbid corpuscles.

56. **ARTERIAL BLOOD** is of lower specific gravity, consequently contains less solid matter, also less fat, albumen, hæmatine, extractive matter and salts than venous blood; the corpuscles also contain less colouring matter, and are stated to be smaller and more uniform in size than in venous blood; but "differences occur in the composition of both kinds of blood, which are not constant, but vary according to circumstances."\*

57. **PORTAL BLOOD** is darker and browner than ordinary venous blood. It is neither reddened by salts nor exposure to the air. It coagulates quickly but imperfectly, and the cohesion of the coagulum is slight. Its serum is reddish, and does not coagulate so quickly or perfectly as that of other blood. It contains an excess of fluid fatty matter, hæmatine and alkaline carbonates, and but little fibrine.

58. **MENSTRUAL BLOOD**, or the menstrual secretion, is a compound of the constituents of the blood with those of ordinary mucus. Its colour is due to the red corpuscles. It also contains mucus and epithelium. In some cases it is very pale, and consists of little more than mucus. The fibrine is small in quantity, and less coherent than usual.

The blood in health contains the following ingredients:—

1. Water.

2. Proteine compounds—fibrine, albumen (globuline,) binoxide and tritoxide of proteine.

\* Simon, Med. Chem.

3. Hæmatine.

4. Fatty matters—3 neutral fats, cholesterine, seroline and phosphorized fat; 3 soaps—margarate, oleate and stearate of soda.

5. Extractive matters—binoxide of proteine (*Ludwig*), tritoxide (*Mulder*.)

6. Salts:— $\alpha$ . Alkaline—sulphates, phosphates, hydrochlorates and carbonates of potash, soda and ammonia.

$\beta$ . Earthy phosphates, carbonates and sulphates of lime and magnesia.

7. Metallic oxides—silica and oxide of iron.

8. Gases—oxygen, carbonic acid and nitrogen.

9. Substances the quantity of which present is exceedingly minute, if any—bile, urea.

10. Matters only occasionally present—sugar.

59. THE ANALYSIS OF THE BLOOD.—Some general remarks on the difficulties presented in the analysis of the blood have already been made. The best processes for its accomplishment will now be noticed.

1. The following process, adopted by Andral and Gavarret, is perhaps the best, being easily practised upon tolerably large quantities of blood. The blood, whilst flowing, is caught in two equal-sized vessels, each holding about  $5\frac{1}{2}$  ounces of water by weight. In one vessel the first and last quarters of the blood are caught; this is set aside to allow of their coagulation. In the other, the second and third quarters are collected; these are immediately beaten with a glass rod to remove the fibrine, which is then carefully washed and dried. When the coagulation of the blood in the first vessel is complete, the serum is carefully separated from the clot, and both are dried. Thus we ascertain the amount of fibrine, of solids of the serum, and of clot; and by the addition of the two latter the total amount of solids is ascertained; the loss is water. The weight of the dried fibrine and of the solids of the serum corresponding to the amount of serum contained in the clot is then deducted from the weight of the dried clot; the difference gives the weight of the corpuscles. The amount of solid matter corresponding to the serum contained in the clot is thus ascertained:—A quantity of solid matter is calculated for the amount of water lost by the clot on drying,

in the same proportion as the solids are to the water in the serum; the weight of this is also deducted from the clot. The quantity of ash may be easily ascertained by separately removing the dried solids from the vessels in which they are contained as perfectly as possible, weighing the portions used, incinerating them, and then calculating the amount for the whole quantity.

2. *Figuier's Process*.—The blood is stirred immediately after having been caught. It is then filtered, the fibrine well-washed, dried, exhausted of fat by æther, and weighed. Some of the blood, freed from the fibrine, is now mixed with twice its volume of a solution of sulphate of soda, of a specific gravity of 1140, or rather less, and the mixture filtered through a previously weighed filter, which has been previously moistened with the saline solution. But few globules pass through. By dipping the filter several times into boiling water, the globules are coagulated and rendered insoluble, and the sulphate of soda removed; the globules are next dried. The albumen is then precipitated from the filtered serum by boiling, washed, dried at  $212^{\circ}$ , and weighed. The amount of water in the blood is ascertained by drying a separate portion. To render this process more perfect, the fibrine, after having been thoroughly washed, should be pressed between blotting-paper, then weighed, and subsequently dried; the difference between the total weight of blood at first taken and the moist fibrine is then estimated, and the amount of corpuscles and albumen calculated for this quantity if a portion only be used. The salts are found by subtracting the weight of the albumen, water, fibrine and corpuscles, which have been directly determined, from that of the blood used.

3. Berzelius recommends the following method:—Two portions of the blood are weighed; one is allowed to coagulate spontaneously, the other is dried in the water-bath and the residue weighed. The loss is the water. When the clot of the first portion is perfectly formed, it is carefully removed, cut up into slices with a sharp knife if large and thick, otherwise this is unnecessary. It is then placed upon an open weighed filter, laid upon several pieces of blotting-paper; another weighed filter is then laid upon it, and more pieces of blotting-paper upon this, the whole



being kept *in situ* by a weight. The serum is absorbed from the clot by the paper, which must be frequently changed, the weighed filters being always preserved. After proceeding thus, until on applying pressure the clot yields no more fluid to the paper, the serum is pressed out as strongly as possible, and the clot dried *in vacuo* over sulphuric acid in the adhering weighed piece of blotting-paper; it is then weighed in a covered vessel, to prevent the absorption of moisture from the air. The weight of the fibrine and globules is ascertained by subtracting the weight of the weighed paper from that of the dried clot. The latter is then treated with water at 77°–86° F., which must be frequently changed; and the remaining fibrine, when it ceases to colour water, is dried and weighed. Thus we learn the relative quantities of fibrine and corpuscles, the latter being obtained from the water used for washing. The dried and weighed blood (second portion) is then successively treated with æther, alcohol and boiling water. The exhausted residue, when well-dried, yields the whole of the albuminous constituents. If the weight of the fibrine and globules be subtracted from it, that of the albumen remains. The æthereal solution contain the fat; the alcoholic and aqueous solutions contains the salts and extractives.\* In making these analyses, particular attention is requisite to one point, which is the method of drying; this is frequently too carelessly managed. It is best accomplished in a platinum vessel; and as soon as the residue ceases to lose weight in the water-bath, as much as possible should be removed from the vessel, and carefully pulverized in a mortar; a weighed quantity of this is then again dried, and if it lose any more in weight, the amount of the whole quantity should be calculated.

To analyze coagulated blood, a modification of Berzelius's process may be adopted. Thus, treat the clot in the manner already described; weigh it after having been freed from the serum as much as possible by the paper; after washing this, weigh the fibrine, freed from as much water as possible, in the same way, by subtracting the sum of these two weights from the total weight of the blood, the amount of

\* Some other processes will be found in the Medical Gazette, vol. xxxvi. p. 547.

serum is ascertained; then by ascertaining the proportion of the constituents of the serum in a given weight of it, the total amount may be ascertained by calculation. The fibrine, corpuscles, &c., may then be dried and weighed as before.

Without detailing Simon's process, it may be well to describe one part of it, which may be occasionally useful in separating the dried blood-corpuscles from other animal matters. It was used by him to separate them from the fibrine and albumen. It depends upon the property possessed by boiling weak spirit (0.925) of dissolving the dried corpuscles, or at least a great part of them. The dried matter is pulverized as finely as possible, the fatty matter removed by æther, and the residue treated with the boiling spirit until this ceases to acquire a red colour, and the residue has assumed a dirty or greenish-gray colour. The spirituous extracts are mixed and set aside; the fluid portion is poured off, evaporated to dryness, the residue powdered and mixed with water into a paste, and then mixed with the flakes which have spontaneously subsided. Strong alcohol is then added, which precipitates the albumen and hæmatine of the corpuscles. If it be required to separate the hæmatine from the albumen (globuline,) this may be accomplished by pouring strong alcohol on the flakes, and adding dilute sulphuric acid in drops until their colour is changed. The mixture is then set aside, the red tincture poured off, and pure alcohol added to the flakes as long as it becomes coloured. If the flakes do not lose their red colour and appear gray, more acid must be added and the process repeated; when however this is the case, the flakes are washed, dried at  $230^{\circ}$ , and weighed. The red tinctures are then collected, supersaturated with ammonia, set aside for some hours, filtered, the sulphate of ammonia washed with alcohol, and finally the alcohol evaporated. The hæmatine remains, containing a trace of fat, and perhaps a little sulphate of ammonia; the latter may be removed by water.

This process does not remove the whole of the corpuscles, so that it is approximative only. A portion of the hæmatine moreover is also decomposed, and Simon's hæmapheine formed. In many cases however it is the only one which can be used.



The incinerations of animal matters and extracts are best performed over a gas burner, or in a muffle in a fire or furnace, the substances being placed in a porcelain or platinum crucible. The operation is performed with a muffle in less time than with any lamp. It is better to burn off the carbon by continuance of the heat, than by the addition of nitric acid or nitrate of ammonia, &c. The ash, when perfectly incinerated, should appear fused. Should any carbon however remain, it may be separated by treating the ash with water and boiling muriatic acid, when it remains undissolved, and may be separated by filtration.

The analysis of the serum may be made,—1st, by evaporating a weighed portion to dryness; the loss indicates the water. The cautions to ensure perfect drying must be carefully attended to. The powdered residue is treated with a small quantity of anhydrous alcohol, and then with æther, until all the fat is removed. The remaining æther is expelled by a gentle heat. The pulverized residue is then treated with *boiling* water, which dissolves the extractives and alkaline salts  $\alpha$ , leaving the albumen and earthy salts  $\beta$ . These may be separated by incineration. The solution  $\alpha$  is evaporated to dryness, and the residue *exhausted* with alcohol, which removes the chlorides of potassium and sodium, with some extractive; the latter is dissipated by incineration. The portion undissolved by alcohol is saturated with acetic acid, evaporated to dryness, and the acetate of soda removed by alcohol; on incineration, it leaves the carbonate; the residue consists of phosphate with a little sulphate of soda. The insoluble portion  $\beta$  is incinerated; the albumen is thus burnt off and the earthy salts left.

2d. A more accurate process is the following:—The serum is evaporated to dryness at  $212^{\circ}$ , the residue exhausted with boiling water, the solution evaporated to dryness, the residue incinerated, the amount of carbonated alkali ascertained from the quantity of a dilute acid required for its saturation; (117) the solution is acidified with nitric acid, and the chlorine precipitated by nitrate of silver in slight excess, the precipitate collected on a filter, dried, fused, &c. The excess of the silver is precipitated by muriatic acid, the solution filtered and treated with nitrate of baryta, the precipitate collected, &c.; excess of baryta is removed

with sulphuric acid; a weighed quantity of pure iron is then dissolved in nitric acid and added to the solution; the mixture is treated with excess of ammonia, which throws down a reddish-brown precipitate of basic phosphate of iron, mixed with oxide of iron;\* this is collected, &c., and strongly heated. The remaining solution contains the alkalis, which may be separated according to 38  $\beta$ . The albuminous residue is incinerated; the earthy phosphates are then left, and may be separated according to 41. The quantity of chlorine is calculated from the chloride of silver, the sulphuric acid from the sulphate of baryta, the phosphoric acid as the difference between the quantity of oxide of iron corresponding to the pure iron used and the mixture of phosphate and oxide. By calculating the quantity of the bases corresponding to the acids, and comparing these quantities with those found by the separate platinum analysis of the residue after the separation of the acids, the amount of the bases may be controlled. The process may be somewhat abbreviated by ascertaining the amount of albumen from a separate portion, and incinerating the second at once to obtain the ash.

The following mean of two analyses by Lecanu and Becquerel and Rodier, will serve to give a general idea of the quantities of the various constituents of the blood, although these are so various that no definite proportions can be fixed:—

Water . . .	78.2867	78.5050		
Fibrine . . .	0.2832	0.2200		
Albumen . . .	6.7252	6.9950		
Fat . . . .	0.5155	0.1610	{	Seroline . . . 0.0020 Phosphorized fat 0.0476 Cholesterine . . 0.0089 Saponified fat 0.1025
Corpuscles . .	12.6313	13.4150		
Alcoholic extractive	0.1855			
Albumen and soda	0.1637	0.09		
Alkaline salts .	0.7837	0.62		
Earthy salts and phosphate of iron }	0.1757	0.0897	{	(Extractives.) . . . . 0.6200 Phosphate . . 0.0344 Iron . . . 0.0553
	100.0000		Total ash .	0.7097

\* If this precipitate be white, too little iron has been used.

Denis, in ten experiments, found the mean amount of saline matter in 100 parts of blood = 1.11.

Nasse obtained 0.7942 per cent. of inorganic constituents from the entire blood ; these were composed of—

Alkaline and soluble salts	{	Phosphates . . .	0.0823	}	0.6672, and
		Sulphates . . .	0.0202		
		Carbonates . . .	0.0957		
		Chloride of sodium	0.4690		
Insoluble substances	{	Sulphuric acid . .	0.0052	}	0.1270 = 0.7942 per cent.
		Phosphoric acid . .	0.0201		
		Lime . . . . .	0.0183		
		Peroxide of iron . .	0.0834		

Becquerel and Rodier obtained—

Alkaline salts . . . . .	0.56, and
Insoluble substances {	Earthy phosphates . . 0.033
	Iron . . . . . 0.056
	} 0.089 = 0.649 total per cent.

On ultimate analysis healthy blood yielded,—carbon, 51.96; hydrogen, 7.25; nitrogen, 15.07; oxygen, 21.30; deducting the ash, C 54.19, H 7.48, N 15.72, and O 22.31.

The dried corpuscles contain about 5 per cent. of hæmatine; the hæmatine contains about 10 per cent. of oxide of iron. The amount of fat in our typical analysis is too great, the average being 0.2 or 0.3 per cent.\* The total amount of saline matters is about 1.0 per cent., that of oxide of iron about 0.06–0.07 per cent.

The following may be regarded as the average composition of serum :—

Water . . . . .	90.600	
Albumen . . . . .	7.900	
Extractives, fat and soda . . . . .	0.599	
Alkaline chlorides . . . . .	0.600	} 0.901
Carbonate, phosphate and sulphate of soda . . . . .	0.210	
Carbonate and phosphate of lime and magnesia . . . . .	0.091	
	<hr/> 100.000	

The fatty matter of the blood requires a few remarks; it

\* I inadvertently stated in the Med. Gaz. that the amount of fat in blood averages 2 per cent. It should be 2 parts in 1000.

has not however been sufficiently examined to enable us to speak positively as to its nature. It is separated by exhausting the dried and powdered blood with water, again drying, and boiling alcohol on the residue. The alcoholic solution should be filtered whilst boiling-hot; on cooling, it deposits seroline. After separating this, on evaporating the alcoholic solution, four fatty matters are found in the extract. When the latter is acted upon by cold alcohol (0·833,) a crystalline fat remains undissolved; this is the phosphorized fat, and somewhat resembles Fremy's cerebrie acid. The alcoholic solution on spontaneous evaporation deposits cholesterine; and after separating this, on further evaporation a mixture of margaric and oleic acids with the potash soaps of these acids is left. Lecanu found in the serum only cholesterine, seroline, margaric and oleic acids, but no phosphorized fat.

The fat extracted from fibrine by æther is crystalline when cold, reddens litmus, and is soluble in cold alcohol, leaving an alkaline ash on incineration; thus it appears, partly at least, to consist of an acid soap.\*

In addition to the ordinary constituents of the blood which we have just detailed, others are occasionally present, even in the healthy fluid.

60. SUGAR is one of these. It has been found by Mr. McGregor, and recently by Dr. Buchanan, that blood, even from an apparently healthy individual, ferments with yeast; this has also been found to occur in diabetic blood. It would be more satisfactory were more positive means adopted to test the presence of sugar in this fluid; as by procuring the sugar in the solid form, or the application of Trommer's or Pettenkofer's tests; the production of carbonic acid, cannot be received as evidence without the growth of the torula (Pt. I. p. 46,) as carbonic acid is evolved from the blood under other conditions.

In applying the fermentation test, the serum should be evaporated to dryness, and the residue treated with boiling water. The solution is then treated with a little yeast, and set aside in a warm place; if sugar be present, the evolution of gas and the formation of the white froth occur.

\* Berzelius.

Trommer's test depends upon the power possessed by sugar, of reducing the suboxide of copper to the protoxide. It is this:—

Add a little solution of sulphate of copper to the suspected liquid, then solution of potash in slight excess, and boil the mixture. The oxide of copper at first precipitated is redissolved by the excess of potash, the liquid becoming deep blue; and if sugar be present, on the application of the heat an orange-red precipitate of suboxide of copper falls; if no sugar be present, the precipitate is almost black. As potash at a boiling temperature frequently causes a dark colour with organic matters, which may obscure the distinct appearance of the reaction, the following method of applying this principle is preferable (Capezuoli's test:)—Add solution of potash to that of sulphate of copper in a test-tube, wash the blue precipitate with water, add it to the suspected liquid, and then enough potash to render the mixture distinctly alkaline. Set the whole aside in a tall glass vessel, no heat being applied. At the end of a few hours, if sugar be present, the blue precipitate is changed in colour, at first upon its surface, finally throughout the whole mass, assuming a canary-yellow tint; this is succeeded by a red one, the protoxide of copper being reduced. This is a beautiful test; the only objection is that it cannot be applied immediately.

The solution may be prepared for its application, either as described above, or by evaporation to dryness, exhausting the residue with boiling alcohol (not strong,) again evaporating to dryness, and treating with water.

**61. BILIC ACID AND BILIARY COLOURING MATTER.**—These two substances appear to occur separately, although mixed in the bile, and we now fortunately possess means of recognising each.

It is doubtful whether bilic acid occurs in the blood, but there is no doubt regarding the occurrence of the colouring matter. In the healthy fluid neither can be detected.

The colouring matter is recognised by the peculiar greenish-yellow colour which it imparts to the fluid, as also by the reaction of nitric acid, which causes it to pass through a series of tints, in which green and red predominate. If the fluid be albuminous, the albumen, when precipitated by



nitric acid, assumes a green colour. Bilic acid its recognised by its reactions with sulphuric acid and cane-sugar (Pettenkofer's test.) The liquid, or an aqueous solution of the solid suspected to contain it, is treated *guttatim* with two-thirds of its volume of sulphuric acid in a test-tube. From 2 to 5 drops of syrup (1 part sugar to 4-5 water) are then added, and the mixture shaken. The addition of the acid at first precipitates the bilic acid, which is subsequently redissolved, and speedily a beautiful deep reddish-violet colour is produced. In using this excellent test, the temperature of the mixture must be kept below  $144^{\circ}$  F.; too much sugar must not be added; the sulphuric acid must be free from sulphurous acid, and albumen must be previously removed by ebullition. In some cases, especially where the amount of bilic acid is small, an excess of the acid may be requisite.

To remove the bilic acid and colouring matter, the fluid should be evaporated to dryness, exhausted with strong alcohol, again evaporated to dryness, and the residue dissolved in a small quantity of water.

This test acts equally well with grape-sugar. If properly applied it does not appear liable to fallacy. Albuminous solutions, when very concentrated, produced a similar reaction. If too much syrup be added, the mixture becomes brown from the formation of humus. A certain amount of heat is necessary, or at least facilitates the reaction.

62. UREA.—In all probability urea exists in the blood in minute quantity, although it cannot be satisfactorily detected. The fact of the extractives of blood causing chloride of sodium to crystallize in octahedra and to form the peculiar dagger-like crystals (Part I. figs. 30 and 31,) cannot be considered as sufficient to decide this point. Some of the crystalline arborizations of muriate of ammonia so nearly resemble those of chloride of sodium crystallized from a solution of urea, that they can hardly be distinguished. In certain diseased conditions there is no doubt of its occurrence. To detect urea in the blood, or in any fluid, evaporate it to dryness in a steam or water-bath, exhaust the residue with strong alcohol, again evaporate, dissolve the residue in a small quantity of water, immerse the mixture in ice-cold water, or in a freezing mixture, and add slight



excess of nitric acid. The compound which separates (and one nearly always does so, whether urea is present or not) must then be examined with the microscope. Two substances are generally to be found, viz. globules of oleic acid, or rather a mixture of oleic and margaric acids, and oblique rhomboids of nitrate of soda; if urea be present, it may be distinguished by its characteristic form (Pl. II. fig. 38.) It is seldom however that it can be recognised at the stage of the process; if not, the liquid should be digested with excess of carbonate of baryta, then gently evaporated to dryness, exhausted with strong alcohol, again evaporated and treated with the acid in the cold as before; if urea be present, its form may then be recognised; the appearances generally presented are figured in Pl. IV. fig. 20. The crystals of the nitrate of soda, as found under these circumstances, are figured in Pl. IV. fig. 21. It is well not to use oxalic acid to separate the urea in this process, as it crystallizes itself in the cold, and may give rise to confusion; moreover, the extracts should be thoroughly exhausted with alcohol, as the amount of urea is generally not large, and the evaporations should be performed very carefully and slowly.

63. MILKY BLOOD.—The occasional occurrence of either an entire milkiness of the serum, or the formation of a creamy scum on its surface by repose, has been noticed in several diseases. It has been lately shown to be almost a constant occurrence in the blood withdrawn a few hours after a meal. The milkiness is caused by an immense number of exceedingly minute granules, resembling in appearance those which form the molecular base of the chyle. They are of two totally distinct kinds, one being soluble in æther, the other unaffected by it. When the milkiness is caused by the former, on agitating the serum with æther it entirely disappears, the serum becoming clear; in the latter case the æther floats on the surface, acquiring a yellowish colour from the solution of fatty matter, the lower portion retaining its peculiar aspect. The former substance is probably analogous to the molecular base of the chyle (*vide* Chyle, p. 129.) Dr. R. D. Thomson found the latter quite insoluble in both æther and alcohol, but soluble in

caustic potash. It contained sulphur. He concluded that it most probably consisted of a proteine compound. Dr. Buchanan found that it might be removed by adding salt to the solution, filtering and washing. In one case the blood has been found milky and acid from the presence of acid fatty salts. I had an opportunity lately of examining some milky blood which had been withdrawn from a gouty patient. It was uniformly white, from the presence of an immense number of minute granules or molecules. These were separated by solution of chloride of sodium. When dried and treated with æther, they yielded some fatty matter. On ebullition with muriatic acid, the characteristic reddish colour of proteine was produced, and a large number of oily globules, which solidified on cooling, floated on the liquid. These were composed of a fatty acid. The substance was in but small quantity, and I have not yet completed its examination. It decidedly contained no sulphur.

64. Pus is an occasional abnormal ingredient of blood. Donné has proposed the action of ammonia as a test of its presence. If healthy blood be mixed with ammonia, the colour becomes somewhat brighter, and the mixture is rendered clear; when containing pus, it becomes gelatinous, the firmness and quantity of the jelly being proportional to the quantity of pus present. This may be a useful test in some cases, but should not alone be relied upon. The microscope may be much more safely trusted. In using this instrument, care must be taken not to mistake the proper chyle-corpuscles (Chyle, p. 129,) or the colourless corpuscles of the blood, for those of pus; the red corpuscles also occasionally present a granular appearance, not very unlike that of globules of pus. The latter may be distinguished from the former by their spherical form, larger size, whitish colour, and yielding nuclei with acetic acid; whilst the former are yellowish, flattened, and dissolved by acetic acid, leaving no nuclei. The colourless corpuscles of the blood much resemble those of pus, but are smaller and more finely granulated on the surface. The proper chyle-corpuscles are also smaller than those of pus, and occur but rarely.

Pus, when mixed with blood, appears in the serum either in the form of the mucous urinary deposit or in flakes.\* (160)

65. **BUFFY COAT.**—The appearance of this remarkable formation is well known. Its ordinary physical properties do not differ from those of fibrine. When freed from the serum by kneading in cold water, and then boiled with water, it yielded 14·2 per cent. of tritoxide of proteine and 85·8 per cent. of binoxide. On organic analysis it yielded—

C 52·53–52·95, H 6·9–7·04, N 15·51, O 25·06–24·5.

Hence it is composed of a mixture of the bin- and tritoxides of proteine. The cause of its formation cannot be explained. It has been observed that if blood be drawn into two separate cups, one of which contains oil, the latter exhibits the buffy coat, whilst the former does not. It is unknown whether the buffy coat is ever composed of fibrine; when produced under the conditions just described, its composition is also unknown.

We have already shown that the oxygen of the air has an undoubted influence upon the corpuscles especially. Now supposing from any cause (and several have been proposed) that the corpuscles in blood which is about to form the buffy coat subside more rapidly, or that the cohesion of the red particles occurring sooner in buffy than in healthy blood squeezes out the *Liquor sanguinis*, which is thus exposed to the air during the coagulation, we can imagine how it *might* occur that in healthy blood during coagulation the fibrine is defended by the corpuscles from the action of the oxygen; whilst in the buffy blood this is not the case, and the fibrine is exposed to the free action of the air, and might form the oxides of proteine. This view would be confirmed *should* the buffy coat formed under oil be found composed of fibrine. These arguments are merely proposed to draw particular attention to the point, and hence to cause the institution of more experiments. I have not noticed Mulder's views on this subject, inasmuch as they do not appear to me at all satisfactory, and he seems to speculate on this matter much more than his experiments entitle him to do.

\* Gendrin.

The microscopic appearances of blood which is about to form a buffy coat are well marked. The formation of the net work perceptible to the naked eye, which in healthy blood does not occur until the lapse of about a minute, may be perceived in buffy blood immediately after its removal from the vessel. Moreover, the fibres formed by the apposition of the sides of the red corpuscles under the microscope are immediately visible; hence buffy blood differs essentially from the healthy fluid, and the formation of the buffy coat may thus be foretold.

Buffy blood contains a larger number of colourless corpuscles than the healthy fluid; but the relation these have to the oxides of proteine is not known. In consequence of the formation of the net work or sponge which we have just mentioned, before the solidification of the fibrine, its contraction is uninterrupted by the latter, and the *Liquor sanguinis* with the colourless corpuscles are squeezed out of the sponge and rise to the surface; so that if we examine a drop from the surface of the blood immediately after it has been drawn into a cup, we find a few colourless corpuscles, as well as the net work of coloured corpuscles; a little later, the latter having sunk, are nearly absent, a few only being detectable, the colourless corpuscles being much more abundant; at a still later period, these having sunk, almost disappear, the solidified fibrine alone being present.

66. CONCRETIONS are occasionally found in the cavities of the heart, which have formed during life. They are composed of fibrine, containing the red corpuscles diffused through them, and, as in the ordinary clot, these are most abundant in the most dependent portion. In the interior of these masses pus is stated to have been found; but, from the observations of Mr. Gulliver, the semifluid matter appears to consist merely of disintegrated pultaceous fibrine; it contains few, if any corpuscles resembling true pus. Nothing is known of its chemical nature. When examined microscopically, it exhibits an immense number of very minute granules with a few lymph (?) corpuscles. It is more prone to putrefaction than pus.

67. CHYLE.—This fluid is so difficult to procure that our knowledge of it is not very satisfactory. It can hardly become an object of pathological examination. It is a neu-

tral milky fluid of about 1021·4 spec. grav., and varying in its properties according to the part of the lacteal system from which it is withdrawn. Soon after its removal from the vessels it coagulates like blood; the coagulum is reddish when viewed in a mass; this redness is said to be increased by exposure to the air; when examined in small quantity it is not perceptible. Its appearance also varies according to the contents of the alimentary canal at the time of the death of the subject from which it is obtained. If a full meal had been taken a few hours prior to death, and especially if this contained fat, the chyle is perfectly milky; but if digestion was not going on, it resembles lymph in its composition. The milkiness depends upon the presence of a peculiar molecular base. It is entirely removed by æther. The reddish colour depends upon the presence of blood-corpuscles. When allowed to repose, the molecular base partly forms a creamy scum on the surface, but the whole fluid does not become clear.

The minute granules, constituting the molecular base, are not changed by the action of the salts, caustic alkalies, nor acetic and muriatic acids. They are instantly dissolved by æther, the chyle becoming transparent, except a small quantity of a light brown or whitish matter, which forms a nearly pellucid *substratum*, sinking towards the bottom of the test-tube, but never entirely reaching it.\*

The fatty matter of the chyle leaves an alkaline ash, and contains no phosphorus.

Chyle (obtained from the thoracic duct) yielded on analysis—

Water	.	.	.	.	.	90·48
Albumen, with traces of fibrine	.	.	.	.	.	7·08
Extractives	{	Aqueous	.	.	.	2·56
		Alcoholic	.	.	.	0·52
Alkaline chloride, carbonate and sulphate, with traces of phosphate and oxide of iron						} 0·44
Fatty matters	.	.	.	.	.	
						<hr/> 100·00†

The differential characters of chyle and blood are as fol-

\* Gulliver.

† Dr. Rees.



low:—The partial or complete absence of the red colour; the low specific gravity; the less distinctly alkaline reaction; the later and more imperfect coagulation; the less number of its corpuscles; their different appearance; the greater amount of fatty matter, but less amount of solids; the imperfect formation of its albumen, which more nearly resembles caseine than the albumen of the blood, and of its fibrine, which more nearly approaches albumen; the free, not saponified state of its fat; its great richness in extractives, diminished quantity of soluble salts; its iron being contained in the serum, instead of the corpuscles; and its greater richness in carbon and poorness in nitrogen than arterial blood.\* Sugar has been found in the chyle, and it would be extremely interesting to know whether urea is ever present or not.

*Microscop. char.*—Before the chyle has passed through the mesenteric glands, it is of a milk-white colour; this is owing to the presence of,  $\alpha$ , an immense number of minute granules, of the  $\frac{1}{24000} \frac{1}{36000}$ th of an inch in diameter (the molecular base;) it also contains  $\beta$ , some free oil-globules; after having passed through the mesenteric glands, it contains,  $\gamma$ , the proper (?) chyle-corpuscles;† these are roundish granulated bodies, some larger and some smaller than the blood-corpuscles, and closely resembling the lymph-globules;  $\delta$ , a few coloured corpuscles of the blood are occasionally present. When treated with æther, the  $\alpha$  and  $\beta$  particles are dissolved, the proper chyle-corpuscles being unaffected. The latter are scarcely affected by acetic acid, nor do they generally yield any distinct nuclei with it, although two or three are sometimes seen.‡ Chyle may be analysed much in the same manner as the blood; more difficulty is however experienced in separating the fibrine, the texture of which is extremely loose and diffuent.

68. LYMPH.—We have even less accurate knowledge of this fluid than of the chyle. It is of a pale yellowish colour, and coagulates in about 10 minutes. The coagulum is gelatinous. It is alkaline, and contains about 3·5 per cent. of solids. It contains much more water than the chyle.

\* Nasse.

† These are surely nothing more than lymph-corpuscles.

‡ Gulliver.



Gmelin found human lymph composed of—

Water	.	.	.	.	.	.	96·10
Fibrine	.	.	.	.	.	.	0·250(?)
Albumen	.	.	.	.	.	.	2·750
Chloride of sodium, free alkali, phosphate of soda,						}	0·210
and a substance resembling ptyaline	.	.	.	.	.		
Extractives and soda	.	.	.	.	.	.	0·690

Marchand found 1·544 per cent. of inorganic constituents.

In microscopic appearance lymph resembles blood which is deprived of the red corpuscles, but it appears to contain a larger number of the colourless globules.

Lymph may be analysed in the same manner as the chyle or serum of the blood.

69. SALIVA.—The saliva, as voided from the mouth, is a mixed fluid, consisting of the secretion of the salivary glands with the mucus of the mouth. When allowed to repose, it separates into two layers; the upper is clear, colourless, and somewhat mucous; the lower consists of the same liquid, containing an opaque matter in suspension. If the saliva be agitated with water, the mucus is diffused through the liquid, and by repose completely subsides. It has a specific gravity of 1005·8, and appears to be alkaline when food is taken, at other times acid. When diluted with water, it is precipitated by nitrate of silver, both acetates of lead, bichloride of mercury and tannic acid; perchloride of iron causes the liquid to assume a deep red colour, from the formation of sulphocyanide of iron. A milkiness is caused in saliva when mixed with water and filtered by acetic, nitric and muriatic acids; ferrocyanide of potassium causes a precipitate in the muriatic solution. Alum also causes a precipitate, but neither this nor the acetic precipitate is soluble in excess of the precipitant. When boiled a very slight opalescence is caused in its aqueous solution.

Berzelius obtained 0·717 per cent. of solid residue from saliva by evaporation. Spirit removes alkaline chlorides, albuminate of soda and extractive from it. The portion insoluble in alcohol is slightly alkaline; when neutralized with acetic acid, evaporated and treated with alcohol, acetate of soda is removed. The undissolved residue consists of mucus and ptyaline.

70. **PTYALINE** somewhat resembles tritoxide of proteine in its characters, but differs from it in some essential points. It is insoluble in alcohol and æther, being precipitated from its aqueous solution by the former, but not by mineral acids, acetic or tannic acids, neither acetate of lead nor bichloride of mercury. It is neutral, and leaves an alkaline ash on incineration.

Ptyaline may be procured by treating the mixture of that substance with mucus, spoken of above, with cold water; the ptyaline is dissolved, the mucus remains. Or, fresh saliva should be neutralized with acetic acid, and then evaporated in a water-bath; the residue is first treated with alcohol and then with spirits; the residue is dissolved in water, and treated with chloride of calcium and ammonia, to precipitate the sulphuric and phosphoric acids; the solution is then neutralized with muriatic acid, evaporated to dryness, and the chlorides extracted with alcohol.\* Ptyaline is stated to have been found in vomited fluids, dropsical effusions, &c.

Berzelius found saliva constituted of—

Water	.	.	.	.	.	99·29
Ptyaline	.	.	.	.	.	0 29
Mucus	.	.	.	.	.	0 14
Extractive and alkali	.	.	.	.	.	0 09
Chloride of sodium	.	.	.	.	.	0·17
Free soda	.	.	.	.	.	0·02
						<hr/>
						100·00

Chloride of calcium, alkaline carbonate, phosphate and sulphate, muriate of ammonia, with phosphate and carbonate of lime and a phosphorized fat, have also been detected in it. Simon found 0·052 per cent. of fat. Tiedemann and Gmelin found 0·25 per cent. of ash, consisting of 0·203 alkaline and 0·047 earthy salts. Saliva contains an exceedingly small quantity of a substance precipitable by acetic, nitric and muriatic acid, as also by ebullition. This appears to consist of albumen with mucus.

The presence of sulphocyanogen in the saliva was clearly shown by Tiedemann and Gmelin thus:—Dried saliva was exhausted with alcohol, the latter removed by distillation, the residue mixed with concentrated phosphoric acid, and

\* Lehmann.

the mixture distilled to dryness in a water-bath; the distilled fluid was reddened by a neutral salt of iron. When a portion of the distillate was treated with a mixture of protosulphate of iron and sulphate of copper, a white precipitate was produced, which possessed the property of reddening an acid solution of perchloride of iron. Finally, a mixture of solution of chloride of barium, chromate of potash and muriatic acid (which is clear, and contains chlorine abundantly,) when added to and digested with the distillate, became turbid, and gradually deposited sulphate of baryta, formed at the expense of the sulphocyanic acid in the distillate.\* The white precipitate spoken of above is  $2\text{CuCy}2\text{S}$ ; the sulphocyanide of copper,  $\text{CuCy}2\text{S}$ , is soluble in water, but is reduced by the protosalt of iron to the sulphocyanuret  $2\text{CuCy}2\text{S}$ . Acetic acid is volatile, but does not cause a deep red colouring in solutions of iron except when previously neutralized by an alkali; moreover, it does not cause the white precipitate with the solution of iron and copper. The red colour of the sulphocyanuret of iron is destroyed by bichloride of mercury; that of the acetate is not so. The meconate and formiate of iron are also of a similar colour to that of the sulphocyanuret; they are however readily distinguished by the bichloride of mercury, which does not destroy their colour. That produced by the addition of chloride of iron to the human saliva is destroyed on the addition of the bichloride.

*Microscop. app.*—This differs but little from that of mucus. Four kinds of corpuscles are recognisable:— $\alpha$ , the minute granules found in all animal fluids;  $\beta$ , mucous globules; these are larger than those in pus, generally yielding a single large nucleus with acetic acid, sometimes not, and being much more slowly acted upon than those of pus;  $\gamma$ , epithelial scales; and  $\delta$ , occasionally a globule or two of oil. In all probability, the whole of these are, save the last, derived from the mucous membrane. The  $\beta$  globules exhibit moving molecules in their interior.

The pathological alterations of the saliva relate to its acidity or alkalinity, the alteration in properties of its normal constituents, and the addition of foreign ones.

The detection of its acidity needs no notice, except that

\* Berzelius.

the paper should be of the most sensitive kind, dahlia-paper prepared without the addition of either acid or alkali; the amount of acid may be estimated according to 117. The proportion of its constituents may be determined by a process similar to that used in the analysis of the serum of the blood. The principal foreign matters, and those which should be sought for, are fat, 21  $\delta$ ; the fatty matter should be washed with water; sugar, 60; acetic acid, 23; albumen, 2  $\delta$ ; urea, 62; bile, 61.

71. CALCULI occasionally form in the salivary ducts. They usually consist of ptyaline, mucus, carbonate and phosphate of lime, alkaline salts, sometimes oxides of iron and manganese. They may be analysed by removing the ptyaline and alkaline salts by water; the remainder is best analysed as in 34  $\epsilon$ . Any animal mixed with these substances may be decomposed by incineration.

72. TARTAR of the teeth being a deposition principally from the saliva, may be briefly noticed here. It frequently contains ptyaline; this may be extracted by water; muriatic acid dissolves the remainder, except the salivary mucus. Ammonia throws down phosphate of lime, ammonia-magnesian phosphate and some animal matter from the solution. Berzelius found per cent,—ptyaline, 1.0; salivary mucus, 12.5; earthy phosphates, 79.0; animal matter dissolved by the muriatic acid, 7.5.

When examined with the microscope, it appears composed of the amorphous substance, minute infusoria, and mucus resembling that of the saliva.

73. GASTRIC JUICE.—Notwithstanding the attention which has been bestowed upon this important fluid and the digestive process, the real nature of the former and the actual part it plays in the latter are still not satisfactorily determined.

The gastric juice is slightly viscid, frothy and colourless, and contains mucus, which impairs its transparency; by filtration however it becomes clear. When digestion is not going on it is neutral, at other times acid. It is composed of free muriatic acid, (?) chlorides of sodium, potassium, ammonium, calcium and iron; extractives; an animal matter, soluble in dilute acids, and precipitable by persalts of copper and iron; mucus, pepsine and phosphate of lime.

It contains neither albumen nor phosphate of soda. Berzelius obtained 1·269 per cent. of solids from it. Beaumont found that it effervesced with carbonated alkalies. We have already described the process from which Dr. Prout arrived at the conclusion that the gastric juice does contain free muriatic acid; there can be no doubt that it does not contain free lactic acid; but it is so difficult to obtain in a pure state, that its properties are likely to remain very obscure.

Various experiments have lately been made, tending to overthrow Dr. Prout's conclusion; but these have unfortunately been instituted upon the gastric fluid mixed with various organic matters which were undergoing digestion, so that on subjecting them to distillation little or no muriatic acid passes over (as pointed out years ago by Tiedemann and Gmelin in their beautiful experiments,) it being probably retained, as they suggested, by the organic matters present. The following experiment of MM. Tiedemann and Gmelin appear very decisive upon this point:—They placed pieces of well-washed limestone in the stomachs of fasting animals, and found subsequently that the gastric juice was no longer acid, but contained a deliquescent salt, which was not decomposed by a red heat, and was proved to be chloride of calcium. Dr. R. D. Thomson distilled the contents of the stomach of a pig after dilution with water and filtration, and found that, although the distillate was acid, it gave no trace of hydrochloric acid with nitrate of silver. 3 portions of the fluid remaining in the retort were next measured out. The first was precipitated by nitrate of silver; nitric acid was then mixed with the liquid and the whole boiled; the precipitate filtered and washed. The second portion was dried and ignited, the residue dissolved in water and precipitated with the nitrate, the solution being acidulated with nitric acid and boiled. The third was exactly neutralized with caustic potash, evaporated and ignited, the residue dissolved in water and precipitated by the nitrate. The results were,—

	Chloride of silver.	Chlorine.	Hydrochloric acid.
1st.	7·81	1·95	2·00
2d.	7·17	1·79	1·84
3d.	7·97	1·99	2·04

Now these experiments appear to me susceptible of a different interpretation to that given by the author; for supposing that no hydrochlorate of ammonia was present, (it has been found absent by Dr. Prout, and in this case was not proved to be present) the chlorine might have existed in the form of muriatic acid and chloride of fixed bases; the first precipitate would therefore have contained the chlorine combined with the fixed bases + that existing as muriatic acid; the second would contain the chlorine of the former alone; the third the same as the first. So that these results are not opposed to Dr. Prout's view.\*

74. PEPSINE has been supposed to be the active principle in digestion. It is contained in the cells composing the walls of the gastric glands. It is soluble in cold and lukewarm water; the solution is troubled by boiling, and then loses its digestive property. It is insoluble in alcohol and æther. Its aqueous solution is precipitated by alcohol, tannic acid, diacetate of lead, and slightly by bichloride of mercury and protochloride of tin; but not by potash, ammonia, alum, nor ferrocyanide of potassium, even in the acidified solution. A drop or two of the mineral acids causes a precipitate, which is redissolved by excess. On incineration it leaves an ash, consisting of carbonate and phosphate of soda, lime and a trace of iron.

Pepsine may be obtained by treating the mucous membrane of the stomach with water and digestion at 90°. At the end of some hours the fluid is poured off, the membrane again washed and treated with cold water until a putrefactive odour is perceptible; it is then filtered, treated with acetate of lead, the precipitate decomposed by sulphuretted hydrogen, the filtered liquid evaporated to a syrup, and the pepsine precipitated by alcohol.

According to Vogel's analysis it consists of,—carbon, 56.723; hydrogen, 5.666; nitrogen, 21.088; and oxygen,

\* I must refer the reader to an interesting paper on this subject by MM. Bernard and Barreswil (*Comptes Rendus*, Dec. 9, 1844, and *Chem. Gaz.*, vol. iii. p. 41,) in which it is considered as proved that the acidity of the gastric juice is caused by free lactic, and not hydrochloric acid. These experiments do not however appear to me free from fallacy.



16·523. Thus differing essentially from all the proteine compounds.

The gastric juice may be analysed in the ordinary way, if it be required merely to ascertain its general composition. Methods for separating particular constituents may be found under the heads of those substances. The compounds of most interest, occurring in it either constantly or occasionally, are the free muriatic acid, pepsine, albumen, acetic, butyric and uric (?) acids, sugar, bile and urea.

It appears that the organic principle of the bile is very speedily removed from the stomach when bile has been poured into that viscus, the colouring matter being left. In "bilious" vomited fluids I have failed to detect it, although the colouring matter was abundant, and the fluid had a bitter taste. The quantity present, if any, was too small to be appreciable by Pettenkofer's test.

*Microscop. char.*—There are none by which this fluid might be distinguished. If the digestive process be a kind of fermentation, either microscopic fungi or animalcules must exist in it, for no fermentation can occur without either one or the other. They have been found in the stomachs of minor animals, and exist frequently, if not constantly, in the human stomach.

The fluid lubricating the intestinal canal has been but little examined, on account of the difficulty of obtaining it. That in the duodenum does not appear to differ from the gastric juice; it is acid during digestion, but nearly neutral when the intestine is empty. That in the large intestine is alkaline, except in the cæcum, where it is acid.\*

75. PANCREATIC FLUID.—Little is known of this liquid. From its examination in animals, it appears to be acid when first secreted, transparent and mucous, containing a large quantity of free albumen, (?) but no sulphocyanic acid. Krause found the human fluid transparent and neutral. Acetic acid caused a whitish precipitate and partial coagulation, which was increased by the application of a gentle heat. It contained minute, spherical, transparent globules, some of which were colourless, others yellowish. They

\* Berzelius.

varied in size from the  $\frac{1}{1060} \frac{1}{400}$ th of a line in diameter averaging the  $\frac{1}{802}$ . It has been observed that a solution of chlorine coloured the pancreatic fluid of a dog bright rose-red, and at the end of 12 hours violet flakes subside. Should this be proved to occur with the human fluid, it might be of the greatest service in enabling us to detect irritation, or other disorder, inducing increased secretion of the pancreas.

76. BILE.—Although this fluid has been repeatedly examined by many excellent chemists, the present opinions regarding the nature of its main constituent are so conflicting, that it is impossible to give any very satisfactory account of it. This arises from two causes,—the facility with which the biliary matter is decomposed, and the absence of organic analyses of several of the compounds obtained from it, whether products or educts. The mass of evidence seems decidedly in favour of its being constituted by one simple electro-negative body combined with the base soda, and mixed with colouring matter, &c. But as there is still some doubt on the point, I shall describe those substances which are obtainable from it, and some of which Berzelius considers to be true educts.

The bile is a brownish-yellow fluid tinged with green; its taste is bitter, and subsequently sweet; specific gravity about 1026; it is not coagulated by heat; is neutral when fresh, speedily becoming alkaline and decomposing; this is prevented by the removal of the mucus, of which it contains a large quantity; it may be accomplished by filtration through linen, inspissated by evaporation, and the addition of alcohol, which dissolves the biliary matter but leaves the mucus; or, more perfectly, by the addition of dilute acetic acid. On digesting the alcoholic solution with animal charcoal and evaporation, it leaves a residue, which is colourless, or nearly so, and soluble in alcohol and water but not in æther. This is the pure biliary matter, which is called bilic acid. Its aqueous solution is not precipitated by acetic acid, but is by the mineral acids, a milkiness and a syrupy liquid separating either immediately or after some time. On the addition of basic acetate of lead to the liquid, the biliary matter is precipitated, a quantity of organic matter, corresponding to the somewhat soluble lead com-

pound, alone remaining in solution.\* The alcoholic solution is not precipitated by acetate of lead;† the aqueous is so, and acetic acid being set free, part of the lead compound is dissolved by this. The portion of biliary matter thus retained in solution was considered by Gmelin and Berzelius as a distinct substance (biliary sugar and biline,) but it is nothing more than pure bile.‡

When incinerated, pure bile left 6·6 per cent. of soda and 1·87 per cent. of chloride of sodium; and on organic analysis it yielded,—carbon, 68·80; hydrogen, 10·40; nitrogen, 3·44; oxygen, 17·36.§

M. Platner has obtained some curious results with the pure biliary matter. He considers that it is composed of two distinct substances, one of which, the main constituent, may be obtained in a crystalline state. This was accomplished by evaporating the bile to dryness, adding absolute alcohol, filtering the solution, and repeating this process several times. Excess of æther was then added to the strong alcoholic solution, and the mixture set aside in the cold; the principal and most important constituent of the bile then crystallized;|| from  $\frac{1}{4}$  of the bile used however did not crystallize, but remained liquid. Liebig considers the crystals as bibilate of soda; they have a slightly sweetish and bitter taste, are very soluble in alcohol and water and very deliquescent. Their solution is neutral, but the deliquesced crystals are acid, this reaction disappearing on the addition of water. The acid solution is not precipitated by acetate of lead, but is so when neutralized; subacetate of lead and nitrate of silver cause white precipitates in the acid solution; muriatic, sulphuric and nitric acids, even when concentrated, cause no opacity. When warmed, muriatic acid causes the solution to become opaque, and deposit oily drops. The oily body is entirely soluble in water.

\* Liebig.

† If the colouring matter and fat have not been separated, a slight precipitate of biliverdine and fatty acids, combined with oxide of lead, subsides.

‡ Liebig.

§ Kemp.

|| These crystals, as I obtained them, formed delicate, silky, flattened needles, mostly arranged in aigrettes.

After removing the crystals, if the æther be distilled, a body remains, which behaves exactly like Gmelin's biliary resin. As this crystalline compound has not been subjected to organic analysis, we are still uncertain as to its nature and relations. In the bile of the minor animals, the composition of the bilic acid seems to be constant; this would tend to render it probable that the bilic acid is a simple body, and not composed of several proximate constituents.

Berzelius, as we have stated, regards the bile as a much more complex fluid. The substances which he considers as entering into its composition will now be briefly described, with some decided products of decomposition of the bilic acid. The former are prepared as follows:—The bile is evaporated to dryness in the water-bath, or *in vacuo* over sulphuric acid, and the temperature finally raised *in vacuo* to 212°. The dried residue is powdered, and exhausted with anhydrous alcohol; mucus, chloride of sodium, and other salts and animal matters are thus left undissolved. The solution contains bilate of soda, alkaline oleate and margarate, colouring matter, &c. It is filtered, and shaken in small quantities at a time with chloride of barium, whereby a green precipitate is formed; this consists of biliverdine and baryta. It is washed with alcohol and water, then decomposed whilst moist by dilute muriatic acid, which removes the baryta. The remaining biliverdine is then dissolved out by alcohol, and is left on its evaporation.\*

If barytic water be added to the solution of bile from which the last compound has been separated, a precipitate of bilifulvine forms in combination with baryta. This is washed with alcohol and water. The latter dissolves out most of the bilifulvine and baryta, leaving a little biliverdine and baryta undissolved.†

The excess of baryta is now precipitated by carbonic acid, and sulphuric acid diluted with alcohol added as long as any precipitation of sulphates occurs. The filtered fluid is mixed with moist carbonate of lead; this removes the sulphuric and some fatty acid; excess of lead is precipitated by sulphuretted hydrogen; the solution is then filtered and evaporated to dryness. When dried, the residue is ex-

\* See 78.

† See 79.

hausted of fat by æther, and consists of biline mixed with a little fellinic and cholinic acids, resulting from its partial decomposition. The latter are removed by gradually adding a little finely divided oxide of lead in small portions; a plastery mass is formed; the solution is filtered, evaporated to dryness, and treated with anhydrous alcohol, which dissolves the biline; the solution should be evaporated *in vacuo*.\*

77. The colouring matter cannot be obtained from the bile in an absolutely pure state. It is almost insoluble in water and alcohol. It is called cholepyrrhine by Berzelius, and is remarkable for the series of tints through which it passes when treated with nitric acid, becoming first brownish, then green, blue, violet, red, and finally yellow or yellowish-brown. It is sometimes suspended in the bile in the form of a yellow powder; at others, enters into the composition of biliary calculi. It is readily soluble in a solution of caustic alkali; the solution yields a green precipitate when treated with muriatic acid. Two other colouring substances are described by Berzelius, which will be next noticed; but whether they are products or educts of the cholepyrrhine is not known. It is highly probable that these colouring matters are mere modifications of one and the same.

78. BILIVERDINE is insoluble in water, slightly soluble in alcohol, the concentrated solution being reddish; also slightly soluble in æther, colouring it red. Sulphuric and muriatic acids dissolve it with a green, and acetic acid with a red colour; æther colours it red. Nitric acid in excess decomposes it, rendering the solution yellow, but not causing the formation of the series of tints, except it be dissolved in an alkaline solution. It has been analyzed by Scherer, who separated it from the urine of a jaundiced patient by chloride of barium. He found it composed of,—carbon, 67·761; hydrogen, 7·598; nitrogen, 6·704; oxygen, 17·937.

During the occurrence of these changes in colour, the substance loses carbonic acid and hydrogen.

79. BILIFULVINE has been but little examined. It is

\* See 80.



best obtained by exhausting the dried bile first with anhydrous alcohol, and then with warm spirit (0·843.) On mixing the latter solution with anhydrous alcohol, it is precipitated, the alcohol is distilled off, the bilifulvine dissolved in water, and the solution precipitated with acetate of lead, the precipitate decomposed by sulphuretted hydrogen, and the filtered liquid evaporated to dryness; the residue dissolved in a small quantity of water, and anhydrous alcohol added to it as long as it occasions a precipitate. This is dried, and is bilifulvine, a compound of bilifulvic acid and soda. When treated with nitric acid, the bilifulvic acid is precipitated. It is insoluble in water and alcohol.\*

80. BILINE (Gmelin's biliary sugar, Thenard's picromel) is colourless or pale yellow, bitter and sweet, soluble in water and alcohol, but not in æther. It may be heated above  $212^{\circ}$  without decomposition. Its aqueous solution is unprecipitated by acids, alkalies and metallic salts. It forms a semifluid compound with potash, and leaves no ash† on incineration. The mineral acids decompose it into fellinic and cholinic acids, dyslysine, taurine and ammonia. Its ready decomposition forms a marked peculiarity. In whatever manner it is procured, it always contains sulphur.‡

Biline may be obtained either by the process above mentioned, or the following:—Fresh bile is acidified with a few drops of acetic acid; neutral acetate of lead is then added; the biliverdine, oleate and margarate of lead are thus precipitated; basic acetate of lead is then added to precipitate the bilifellinic acid; the plastery precipitate is separated by filtration, and the filtered solution decomposed by excess of carbonate of soda; the precipitate is then exhausted with absolute alcohol, and the alkali thrown down from this solution by dilute sulphuric acid, cautiously added; on evaporating the alcoholic solution to dryness, the biline is left.

Liebig considers that the substance called biline is nothing more than pure bile, held in solution by the acetic

\* Löwig.

† Theyer and Schlosser obtained a strongly alkaline ash.

‡ Lehmann.



acid set free on treating the bile with acetate of lead, as nearly the whole of the bilic acid is precipitated by the basic acetate of lead.

81. **FELLINIC ACID** appears to be nothing more than a combination or mixture of cholinic with choleic acid.\* It is formed by digesting biline or purified bile with dilute muriatic acid for some time. At first an oily fluid (bilifellinic acid,  $\alpha$ ) separates; the digestion is continued until water, which has been poured on the residue of the decanted fluid, ceases to be rendered turbid, when a little of the latter is added to it. The separated mass is then washed with warm water, the water being subsequently added to the acid; it contains taurine and chloride of ammonium. (If the soda has not been removed from the bile, it also contains chloride of sodium.) The residuary mass consists of fellinic and cholinic acids, and dyslysine.† The two former are removed by cold alcohol (0·84,) in which they dissolve; the dyslysine remains insoluble. The solution is mixed with several volumes of water, and set aside for some hours. A precipitate, consisting principally of cholinic acid, is formed, but the liquid does not become clear. The fellinic acid principally remains in solution. The precipitate is treated with solution of carbonate of ammonia; this dissolves the fellinic acid, leaving an acid choline of ammonia undissolved. The first fellinic solution is evaporated to a syrup, and also treated with the carbonate of ammonia. The ammoniacal solutions are then evaporated to dryness, the residue digested with water, and the solution decomposed by muriatic acid. The acid separates in white flakes. It is but little soluble in water, more so in æther, and readily in alcohol. It leaves no ash. Its alkaline salts form white plastery precipitates with salts of baryta. It contains no nitrogen.‡

82. **BILIFELLINIC ACID.**—This exists in two forms,—one,  $\alpha$ , containing a maximum, the other,  $\beta$ , a minimum of

\* Liebig.

† Demarçay's choloidic acid.

‡ Since purified bile affords no precipitate with either barytic water or chloride of barium and ammonia, fellinic acid does not exist in it.

biline. The latter is obtained from the bile which has been purified from mucus, colouring matter, and other acids, with acetate of lead, by precipitation with the basic acetate. It falls in flakes, which form a plastery mass. It is separated by decomposing the lead salt with carbonate of soda at a gentle heat; and the soda salt, by sulphuric acid. It may be purified from sulphuric acid by carbonate of lead, and from fellinic and cholinic acids by æther. It forms a syrupy acid liquid, is bitter, readily soluble in hot alcohol, little so in cold, as also in hot water. It is Demarçay's choleic acid.\*

The bilifelline acid  $\alpha$  is decomposed by oxide of lead into bilifellinic acid  $\beta$ , biline being set free; it is unaffected by æther. The bilifellinic acid  $\beta$  is resolved by æther into bilifellinic acid  $\alpha$ , fellinic and cholinic acids; the latter are dissolved by the æther, the former is insoluble.

83. TAURINE is obtained in the process described for procuring fellinic acid. The solution is evaporated to dryness, the residue treated with alcohol; (0 84) this dissolves the muriate of ammonia and chloride of sodium, leaving the taurine in white crystals. These are six-sided prisms, with four or six-sided summits, soluble in water, but little so in alcohol. Taurine is neutral, and not precipitated by acids nor metallic salts. It consists of  $C^4 H^7 N O^6 S^2$ , yielding C 19·19, H 5·59, N 11·19, O 38·39, S 25·59; the numbers found were C 19·34, H 5·67, N 11·19, O 38·00, and S 26·00. No indication of the presence of the sulphur is obtained by boiling taurine with potash and oxide of lead;† it is however by the method recommended in 30, the only safe test of the presence of sulphur.

84. DYSLYSINE is obtained in the preparation of fellinic acid. It resembles resin; is but little soluble in alcohol even when boiling; the latter solution deposits an earthy powder on cooling; it is insoluble in water.

85. CHOLINIC ACID is obtained by decomposing choline of ammonia (81) with dilute muriatic acid. It separates in white flakes, which when dry are readily pulverized. It is insoluble in water, soluble in alcohol, but little in æther.

\* Berzelius.

† Dr. Garrod.

It differs from fellinic acid by swelling in alkaline carbonates, without however dissolving either in them or in water subsequently added. Its barytic compound is insoluble in water.\*

86. CHOLEIC ACID is obtained by boiling bile or the alcoholic solution of the bile with potash as long as ammonia is evolved; the liquid is evaporated, the residue dissolved in water and decomposed by acetic acid. It crystallizes in needles, is slightly soluble in water, readily so in alcohol. It is composed of  $C^{42} H^{36} O^{10}$ . The cholates are mostly soluble in water, and possess a sweet taste.

87. CHOLEIC ACID.—Demarçay obtained this substance from bile by dissolving the alcoholic extract in water, and precipitating with acetate of lead, the free acid being neutralized by ammonia. The plastery precipitate is washed and boiled with alcohol; this dissolves what Demarçay supposes to be an acid salt, leaving a basic one. The lead is removed by sulphuretted hydrogen, and evaporated to a syrup, treated with æther, and then completely dried. It forms a spongy, very bitter mass; is insoluble in æther, readily so in alcohol and water. Demarçay considers it as the principal component of the bile. Berzelius regards it as his bilifellinic acid  $\beta$ .†

It is composed of C 21, H 36, N 2, and O 12. It contains an undetermined amount of sulphur.‡

88. CHOLIODIC ACID is obtained in the form of a solid deposit, by boiling bile with excess of muriatic acid. It is yellow and bitter, readily soluble in alcohol, but little in water, and almost insoluble in æther. Berzelius considers this as a mixture of fellinic and cholinic acids with dyslysine.

As we have stated, it is uncertain how many of these compounds are present in the undecomposed bile. The composition of the bile, according to Berzelius's view, may be stated thus:—

\* The non precipitation of the pure bile by the addition of either barytic water or chloride of barium and ammonia, proves that it does not pre-exist in the bile.—*Liebig*.

† Lehrbuch, vol. ix. p. 260.

‡ Dr. Garrod.

1. Water.
2. Mucus.
3. Colouring matter :—Cholepyrrhine  $\left\{ \begin{array}{l} \text{Biliverdine} \\ \text{(bilifulvine.)} \end{array} \right.$
4. Fatty matter  $\left\{ \begin{array}{l} \text{Fats:—Seroline, cholesterine, phosphorized fat.} \\ \text{Soaps:—Alkaline oleate and margarate.} \end{array} \right.$
5. Biline, bilifellinic and cholinic acids.
6. Salts :—Chloride of sodium.
7. Bases :—Soda (traces of oxide of iron.)

In a quantitative proximate analysis of the bile, Berzelius obtained—

Biline, fellinic acid, fat, &c.	8.00
Mucus	0.30
Alkali (which was combined with the biline, fellinic acid, &c.)	0.41
Chloride of sodium and extractives	0.74
Phosphates of soda and lime, and a trace of an animal matter insoluble in alcohol	0.11
Water	90.44

89. The method of detecting the biliary colouring matter has been already described. In an albuminous fluid, the green colour which it imparts to the albumen, precipitated by nitric acid, is evident when a minute quantity only is present. In some cases I have seen the liquid coloured greenish-yellow by nitric acid, when the albumen remained perfectly white. Sometimes the reaction may be made evident by treating the fluid or solid with solution of potash prior to the application of the acid.

The detection of the bilic acid is described at p. 122. It does not however appear to occur in animal fluids.\* When suspected, it may be precipitated by basic acetate of lead, the supernatant liquid decanted, the precipitate decomposed by digestion with a little dilute sulphuric acid, and the resulting fluid poured off, and subjected to the reactions of Pettenkofer's test.

90. The quantitative analysis of the bile may be effected either by estimating the bilic acid as a simple substance, or separating the bilic acid and biline.

For the former purpose, it should be dried in a water-bath or *in vacuo*, the residue pulverized and exhausted with

\* Of course excepting the bile.

æther, and subsequently with anhydrous alcohol, and digested for 12 hours with animal charcoal; the solution is filtered, evaporated to dryness, and the residue incinerated. The loss indicates the amount of bilic acid; the residue consists of carbonate of soda.\*

The second method requires the separation of mucus by filtration and alcohol, and of the colouring matter by animal charcoal. The bilic acid is then precipitated by slight excess of basic acetate of lead. The fluid is gently warmed and filtered. The precipitate consists of chloride of lead, and corresponds to the chloride of sodium which was dissolved in the alcohol. The latter is then evaporated, the residue washed with water, dried and weighed; it is bilate of lead. By incineration, the amount of base may be ascertained. The biline is obtained from the filtered liquid by decomposing the remaining lead with sulphuretted hydrogen. The solution is filtered, evaporated, the residue dissolved in alcohol, and the soda precipitated by sulphuric acid, again filtered, and the excess of acid separated by acetate of lead. The lead is then removed by sulphuretted hydrogen, the filtered solution contains the biline and acetic acid. The latter is removed by evaporation.† Or the biline, mixed with the acetate of soda, may be dried and then incinerated; the resulting carbonate of soda corresponds to the acetate, and the difference between the weight of the dried extract and the acetate of soda, calculated from the carbonate, is equal to the biline. The amount of mucus is ascertained by incinerating the portion at first left undissolved by the alcohol; it corresponds to the loss.

The microscopic appearance of the bile presents nothing characteristic. It is not uncommon to find minute amorphous particles of the colouring matter diffused through it. The mucous appears to resemble that of most other mucous membranes.

91. BILIARY CALCULI are generally composed of either inspissated bile, cholesterine, or a mixture of the two; they frequently also contain the mucus of the gall-bladder. They are usually lighter than water, and may be analysed as fol-

\* With chloride of sodium, if absolute alcohol has not been used.

† Löwig.

lows:—They should be first powdered, and the dried bile extracted by water. The powder is next exhausted with æther, which removes cholesterine and other fatty matters; these may be separated by solution in boiling alcohol, which deposits cholesterine on cooling. The remaining powder is then treated with boiling alcohol, which removes fellinic, cholinic acids, &c., if present. The colouring matter is then removed by solution of carbonate of ammonia; potash subsequently dissolves mucus or proteine compounds; the latter may be separated by excess of acetic acid, in which they dissolve, leaving the mucous insoluble. The process will however require to be varied according to circumstances. Copper has been found in those calculi which contain any amount of colouring matter.

92. EXCREMENT.—The excrementitious matters forming the fæces have been elaborately examined by the indefatigable Berzelius, upon whose process I shall base my observations; the method pursued may be also well applied for their general examination.

When fæces are mixed with water, well stirred and set aside, one part dissolves, another remains insoluble. By filtration through linen, these are separated; the insoluble portion is composed of undigested substances. The liquid part is allowed to repose, and filtered through paper; an insoluble part (B) remains, a soluble (A) passes through.

If a portion of the fluid be set aside, ammonia is formed, and a scum of crystalline triple phosphate is found on the surface. If the solution be evaporated by a gentle heat to the consistence of a thin extract, and then treated with alcohol, this dissolves one portion, ( $\alpha$ ) acquiring a reddish brown colour, whilst a grayish brown matter is separated. ( $\beta$ )

1. When the alcoholic solution is mixed with a little water, the alcohol distilled off, and a little sulphuric acid added, a brownish precipitate falls, more of which is formed on evaporating the solution. This is composed of bilifellinic acid,  $\alpha$ , and may be resolved into biline and bilifellinate of lead by oxide of lead, but the biline is very brown.

If the mixture be distilled with sulphuric acid, a liquid containing no acetic acid, but a trace of muriatic acid,



passes over; and if, after the separation of the biliary resin, the sulphuric acid be neutralized with carbonate of lime or baryta, the solution evaporated, and the residue treated with alcohol, sulphate of lime or baryta is left, and a reddish-brown extractive matter is dissolved, which remains transparent after the evaporation of the alcohol. It is soluble in water and alcohol; the first solution is reddened by acids, and is almost completely precipitated by tin, lead and silver salts, also by tannic acid. It contains some alkali, and appears to be the cause of the alteration in the colour of the solution on exposure to the air.

2. That portion of the excrements soluble in water left, as we have seen, a certain quantity of substance insoluble in alcohol, consisting principally of albumen coloured brown by bile, and alkaline sulphate and phosphate, which are left on incineration.

3. The portion of the excrement (B) consists of intestinal mucus, and the matters precipitated by the bile. It is very "mucous." It swells in water, is soluble in caustic potash, and reprecipitated by acids, the fluid evolving an odour of bile.

Alcohol and æther extract fat and bilifellinic acid ( $\alpha$ ) from it. The fat, removed by æther, is dissolved by caustic potash. After it has been treated with alcohol and æther, a matter is dissolved by warm water, which colours it yellow; on evaporation, it leaves a brownish extractive mass, which does not again completely dissolve in water. It is insoluble in alcohol; its solution is troubled by diacetate of lead and tannic acid; the latter disappears by heat. By the continued action of alcohol or æther and water, more biliary resin and matter soluble in water can be removed; but finally an insoluble mass remains. This is probably intestinal mucus coloured by biliary colouring matter, and is soluble in caustic potash. Dried excrement yields about 0.15 per cent. of ash, consisting of phosphate of lime with phosphate of magnesia, and a trace of sulphate of lime, 0.1; carbonate of soda, 0.008; sulphate and phosphate of soda, with a little sulphate of potash and silica, 0.018.

Berzelius obtained by analysis—

Water . . . . .	75·3	
Soluble in { water {	Bile . . . . .	0·9
	Albumen . . . . .	0·9
	Peculiar extractive . . . . .	2·7
	Salts . . . . .	1·2
Insoluble residue of food . . . . .	7·0	
Matters added by the intestinal canal and its appen- dages, as mucus, biliary resin, fat and peculiar extractive . . . . .	} 14·0	
<hr/>		
	100·0	

The salts, extracted by water from 3 oz. of fresh fæces, Berzelius found thus constituted:—

Carbonate of soda . . . . .	3·5
Chloride of sodium . . . . .	4·0
Sulphate of soda . . . . .	2·0
Phosphate of lime . . . . .	2·0
Phosphate of magnesia . . . . .	4·0
	<hr/> 15·5

93. The examination of the fæces, both in health and disease, although certainly a most unpleasant task, is undoubtedly more important than that of any other excretion, and will certainly throw great light on many points both in physiology and pathology. We have lately learned that the bilic acid and the colouring matter of the bile have no essential connexion with one another, and that the detection of the one does not permit of our drawing any conclusion as to the presence or absence of the other. The bilic acid appears to be very rapidly removed from the intestines; and although the colour of the fæces may have the normal depth of tint, there is generally barely more than a trace of the bilic acid to be detected. The two however are apparently secreted in certain tolerably definite proportions; so that, by the appearance of the one in the fæces, we may judge with tolerable accuracy of the probable amount of the other, which has been secreted, but has disappeared from absorption. We are unacquainted with the causes of the variation in the colour of the fæces, exclusive of the depth of normal tint dependent upon the presence of the colouring matter of the bile in greater or less quantity. The changes seem however principally to occur after the bile has been poured

into the intestine;\* for that fluid, in ordinary cases, differs remarkably little from its normal characters, judging from its appearance in the gall bladder, as discovered by *post mortem* examinations. In some cases, especially diarrhœa, the bilic acid seems to occur in the fæces in considerable abundance. The principal abnormal constituents of the fæces are fatty matters, sometimes in great abundance; undigested portions of food, particularly vegetables;† sugar; free albumen; fibrine, or the oxides of proteine, in the form of false membranes, sometimes representing casts of the intestines; urea; increased quantity of mucus; the earthy phosphates, either crystalline or amorphous; blood; alkaline salts, and the various ordinary products of putrefactive fermentation, necessarily accompanying which are infusoria.

After the use of mercury as a purgative, the motions are green, especially in children; this arises from the presence of an increased quantity of the biliary colouring matter, the corresponding bilic acid being also present in greater proportion than natural. Simon obtained from 100 parts of the dry residue—

Green fat, containing cholesterine . . . . .	10·00
Substance resembling pyaline, soluble in water only, and but slightly precipitated by tannic and acetate of lead . . . . .	} 24·30
Bilene, with bilifellinic acid and biliverdine, together dissolved by anhydrous alcohol . . . . .	
Extractive soluble in dilute alcohol . . . . .	11·00
Albumen, mucus, and epithelial cells . . . . .	17·10
Salts . . . . .	12·90

Calculi are sometimes formed in the alimentary canal; they usually consist of undigested portions of the vegetable food, as the hairs on the oat, &c. They are best recognised by the microscope.

94. MILK.—The ordinary appearances of milk are too well known to require description. It is slightly alkaline; spec. grav. about 1030. Its opacity is caused by a very large number of oily globules. When perfectly dried, it

\* I believe that great benefit would arise in practice from attention to this suggestion.

† The microscope is of infinite service in unmasking the nature of these substances.

leaves 10-15 per cent. of residue, and on incineration yields 0.1-0.25 per cent. of ash, one-third of which consists of soluble salts. It is coagulated by acetic, lactic, and most dilute acids, as also rennet. After having been coagulated by rennet or lactic acid, the filtered solution is coagulated on ebullition. The substance thus precipitated has been considered as albumen, and denominated *zieger*; it is however nothing more than caseine. When set aside, a white scum gradually forms on its surface, constituting the cream; this is composed of the light globules, a small portion of caseine, and a little serum, retained interstitially by the globules. The spec. grav. of cream is about 1024. By churning, the globules are beaten into union, and butter is formed. The fluid which remains is butter-milk. Butter consists of stearine, elaine and butyrine; it is easily saponified, yielding 88.5 per cent. of fatty acids combined with glycerine; these consist of stearic, oleic, caprylic, and capric with butyric and caproic or vaccinic acids. Many of these substances have been described; those which are peculiar to the milk will now be noticed.

95. CAPROIC ACID is a volatile fatty oil, which remains fluid below  $16^{\circ}$ , boils at a temperature above  $212^{\circ}$ , has an odour resembling that of perspiration and dilute acetic acid, is but little soluble in alcohol and æther, readily so in anhydrous alcohol. Its barytic salt crystallizes in long silky needles, which are aggregated into bundles, anhydrous, and unchanged by exposure to the air. Caproic acid consists of  $C^{12} H^{11} O^3$ .\*

It may be obtained in the same manner as butyric acid, from the caproate of baryta (p. 77,) which must be purified by recrystallization.

96. CAPRIC ACID is volatile and fluid, solidifies at  $5^{\circ}$ , boils above  $212^{\circ}$ , and is but little soluble in water and æther. It is composed of  $C^{20} H^{19} O^3$ .

Its barytic salt is very difficultly soluble, anhydrous, unaffected on exposure to the air, and crystallizes in needles and scales. Chevreul's caprate of baryta consists of two distinct salts, the true caprate and the capryllate.

Capric acid may be obtained from the caprate of baryta,

\* Lerch, Chem. Gaz., vol. ii. p. 379.

(p. 77.) This exists in the saline mass which remains undissolved in the first portion of water (p. 77,) and is separated by dissolving it in as much boiling water as is requisite for perfect solution and filtering whilst hot. On cooling, caprate of baryta subsides in minute scales. More is obtained on the further evaporation of one-fourth of the liquid. It is purified by re-crystallization.

97. CAPRYLLIC ACID forms a greasy mass, crystallizes below  $50^{\circ}$ , and is difficultly soluble in water. It is composed of  $C^{16} H^{15} O^2$ .

Its barytic salt is anhydrous, permanent, does not fuse at  $212^{\circ}$ , and is very sparingly soluble in water.

The capryllate of baryta remains in the mother-liquor from which the caprate of baryta has subsided; by spontaneous evaporation and re-crystallization it is obtained pure.

It has been stated above, that on the saponification of butter, instead of butyric and caproic acids, we sometimes obtain another, having the same saturating capacity as the two former conjointly, but probably containing less oxygen; this is

98. VACCINIC ACID.—It has not been perfectly examined.

Its probable composition is  $C^{20} H^{18} O^5$ ; it is a bibasic acid.

Its barytic salt is efflorescent, has a strong odour of butter, is of about the same solubility in water as the butyrate of baryta, and contains an undetermined amount of water. Vaccinic acid is readily decomposed into butyric and caproic acids.

99. SUGAR OF MILK has a slightly saccharine taste.

*Chem. prop.*—It is soluble in 6 parts of cold, in 3 parts of hot water; is insoluble in absolute alcohol and æther, but dissolves in dilute alcohol in greater proportion as its strength is less. By the ebullition of its solution with dilute muriatic, sulphuric or acetic acids, it is converted into grape-sugar. When strongly heated it fuses, gives off 11.9 per cent. of water, and solidifies into a crystalline mass on cooling. Fixed alkalies convert it at a high temperature into oxalic acid. Its aqueous solution is not precipitated by bichloride of mercury, tannic acid, nitrate of silver, nor either acetate of lead; but it is so by strong alcohol; the sugar

falls in a crystalline state. With strong nitric acid it yields saccharic, mucic and oxalic acids. On incineration it leaves 0.1–0.4 per cent. of ash, consisting of phosphate of lime. It ferments difficultly with yeast and produces alcohol, mucous sugar being formed at the same time; this fermentation probably ensues in mucous or grape-sugar which is formed from the milk-sugar, by the action of the lactic acid produced.

It consists of  $C^{12}H^{10}O^{10} + 2HO$ ; yielding carbon, 40.46; hydrogen, 6.60; and oxygen, 52.93.

It exists in human milk, forming about 4.7 per cent., or two-fifths of the solid residue; and yields the same reactions with Trommer's and Pettenkofer's tests as the grape or diabetic sugar.

*Microscop. char.*—It forms four-sided prisms when slowly crystallized, otherwise the curious forms figured in Pl. IV. fig. 23.

The following are the components of milk:—

1. Water.
2. Caseine.
3. Fatty matters.  $\left\{ \begin{array}{l} \text{Neutral, elaine, stearine, butyrine.} \\ \text{Acid, elaic, stearic, butyric, capric, caproic,} \\ \quad \text{capryllic or vaccinic.} \\ \text{Basic, glycerine.} \end{array} \right.$
4. Extractives.
5. Salts.  $\left\{ \begin{array}{l} \text{Alkaline, muriates and phosphates of potash, soda, and} \\ \quad \text{ammonia with soda.} \\ \text{Earthy, chloride of calcium, phosphate of lime and} \\ \quad \text{magnesia.} \end{array} \right.$
6. Trace of oxide of iron.
7. Sugar.

The ash of evaporated milk yields alkaline sulphate, a product of the oxidation of the sulphur of the caseine combined with soda and potash.

100. The analysis of milk is difficult, on account of the caseine being somewhat soluble in the reagents ordinarily used in the analysis of organic fluids, especially when mixed with salts.

The following is that of M. Haidlen, perhaps the best:—

Burnt gypsum is moistened with water, so as to allow of its combination with its water of crystallization, gently



dried, finely powdered, and again dried in a water-bath. One-fifth part of this by weight is then boiled with the milk, the whole evaporated to dryness in the water-bath, and weighed; the weight of the residue *minus* that of the gypsum is equal to that of the solid contents. These are then powdered in a warm mortar,\* and the powder put into a weighed flask; the weight is then again taken, and the powder is treated with æther, until all the fat is removed, dried at  $212^{\circ}$  in the flask and weighed. It is then digested with boiling alcohol (0·85,) placed on a weighed filter and well washed with alcohol. The residue is the caseine with the sulphate of lime, the sugar and soluble salts being dissolved by the alcohol. By deducting the weight of sulphate of lime from that of the residue, the weight of the caseine is obtained. The salts may be separated from the sugar by incineration; but their analysis is best made from a separate portion.

The following analyses may be regarded as expressing the average composition of milk:—

	human.		From the cow.
Water . . . . .	88·36†	89·2‡	85·7†
Solids . . . . .	11·64	10·8	14·3
Butter . . . . .	2·53	3·4	4·0
Caseine . . . . .	3·43	3·1	7·2
Sugar and extractives	4·82	4·3§	2·8
Fixed salts . . . . .	2·30		0·62

Haidlen obtained 0·49 per cent. of ash from cow's milk; it consisted of—

Chloride of sodium . . . . .	0·024	} 0·210 soluble salts.
Chloride of potassium . . . . .	0·144	
Soda . . . . .	0·042	
Phosphate of lime . . . . .	0·231	} 0·280 insoluble salts.
Phosphate of magnesia . . . . .	0·042	
Phosphate of the peroxide of iron	0·007	

*Microscop. char.*—The globules of milk are of extremely

\* The quantity used for the second operation must be weighed, and the result calculated for the residue.

† Simon.

‡ Haidlen.

§ Sugar only.

various sizes, they have been figured in Pl. II. fig. 32. They have no tendency to coalesce; this arises from their being coated with a delicate layer of caseine which envelopes them, and is perfectly structureless. If a little acetic or lactic acid be added to milk, the membranes are dissolved and the fatty globules unite; they also then become readily soluble in alcohol and æther, whereas in ordinary milk they cannot be dissolved by either of these reagents. The demonstration of these coverings is a matter of great difficulty. Donné recommends that a drop of milk be placed between two pieces of glass, and that these be rubbed over each other; by this means they become ruptured and visible; I have not, however, been able to distinguish them by this, nor any other means which I have adopted; nor can I distinguish any difference in the surface of these globules and those prepared by triturating water with oil and sulphate of lime or any insoluble powder, which causes its subdivision into exceedingly minute globules. The globules appear to be rather larger in human than in cow's milk.

When milk is kept in a warm place, free lactic acid speedily forms, this precipitates part of the caseine, at the same time the minute vegetable forms, spoken of in Part I. p. 47, are found in it. After milk has been coagulated by rennet or an acid, a portion of the caseine remains in solution; this has been called *zieger*; it is coagulated by heat.

101. The first secreted milk or colostrum is alkaline, and differs from that which occurs subsequently, in containing more solids, fat and salts. The corpuscles in it are also different; they are of two kinds, one consisting of fat globules, which are partly larger than in the ordinary milk, and frequently coalescing; the second is composed of granulated, yellow rounded corpuscles, which are larger than those of the milk, and are apparently composed of aggregated very small fat globules. See Pl. IV. fig. 26.

102. SEMEN.—This fluid is always found mixed with that of the prostate gland. It is thick and viscid, having an odour somewhat resembling that of rasped bones, or a very strong solution of carbonate of soda. Before it has been retained in the *vesiculæ seminales*, it is more aqueous. The odour does not depend upon any substance dissipated

by heat, for on moistening the dried fluid it is again perceptible. It is slightly alkaline, and coagulated by heat, nitric acid and the ordinary tests for albumen. Vauquelin found that semen spontaneously deposited crystals of phosphate of lime. I have some of these obtained from dried semen; they were undoubtedly composed of phosphate of lime; they are figured in Plate IV. fig. 29.

When dried, semen leaves about 10 per cent. of solids; Vauquelin found these composed of peculiar extractive 6·0, phosphate of lime 3·0, and soda 1·0.

Semen contains a remarkable mucoid substance, which does not appear to be in solution but suspension; some time after the fluid has been emitted this substance gradually dissolves, and the solution is no longer coagulated by heat.\* It is soluble in acetic acid, and the solution is precipitated by ferrocyanide of potassium. It has been called spermatine. If the semen be put into water at once, it does not dissolve, but forms a fibrous coagulum. The fresh semen is dissolved by all acids, even the uric and tartaric, and alkalies cause no precipitate in the solution.

*Microscop. char.*—The semen mixed with the prostatic fluid (as it ordinarily occurs) contains five different kinds of bodies:— $\alpha$ , the spermatozoa, which are figured in Pl. IV. fig. 29;  $\beta$ , mucous globules, usually very large and distinct;  $\gamma$ , some of a whitish-yellow colour, not half the size of the last, and having neither a granular surface nor a nucleus;  $\delta$ , the ordinary organic molecules; and lastly, epithelial scales.

We rarely have the opportunity of examining the seminal fluid, and when presented to us, it is generally in the dried state. The spermatozoa are the readiest objects by which it can be detected, but these are not invariably present. When semen is mixed with the urine, the latter becomes slightly albuminous, and the spermatozoa may be found in the deposit. If the deposit, or any fluid suspected to contain these animalcules, be allowed to evaporate nearly to dryness, they may frequently be much more readily detected than by the ordinary method.

103. TEARS.—The fluid of which these are constituted

\* Berzelius.

is alkaline, mucous and watery. On evaporation it leaves about 1 per cent. of solid residue ; this consists principally of chloride of sodium and ammonium, with a yellowish extractive matter not completely soluble in water, and a small quantity of soda.

On microscopic examination it exhibits mucous corpuscles, organic granules and a few epithelial scales.

104. PERSPIRATION.—The history of this important fluid is very imperfect. It does not differ materially from any other dilute mucous secretion. It is slightly acid, has a spec. grav. of 1003–1004, and consists of fat, mucus, sometimes butyric, carbonic and acetic acids and their salts, chloride of sodium and ammonium, phosphate of soda and lime, a trace of oxide of iron. Anselmino obtained from  $\frac{1}{2}$  to  $1\frac{1}{4}$  per cent. of solid matter. According to his analyses, the proportion of constituents in 100 parts of perspiration, yielding 1 part of solids, was

Water . . . . .	99·00
Aqueous extractive with sulphates . . . . .	0·21
Alcoholic extractive with acetates . . . . .	0·29
Chloride of sodium and spirituous extractive . . . . .	0·48
Phosphate of lime, epithelium and oxide of iron . . . . .	0·02

The average quantity of perspiration was found by Seguin to be 11 grs. per minute, equal 33 oz. *per diem*.

*Microscop. char.*—It exhibits mucous corpuscles, epithelial scales and organic granules.

105. CERUMEN.—This semi-solid substance is a kind of emulsion, consisting of soft fat and albumen ; a yellow, very bitter alcoholic extractive matter ; an aqueous extractive ; soda, potash and lime, in combination with animal matter, but neither alkaline chloride nor phosphate.

The fatty matter consists of a mixture of stearine, cholestérine and oleine, and is removed by æther ; alcohol then dissolves the bitter extractive, which on evaporation forms an uncrystallizable residue, the aqueous solution of which differs from the aqueous extractive of other animal fluids in not being precipitated by either lime-water, diacetate of lead, bichloride of mercury, or tannic acid. When incinerated, it leaves an ash, consisting of carbonate of soda and lime. The portion of cerumen left undissolved by æther or alcohol yields a small quantity of extract to water, which is

not precipitated by lime-water, basic acetate of lead, or bichloride of mercury. That portion undissolved by æther, alcohol and water, consists of a mixture of albumen and epithelium. The former is dissolved by acetic acid, the latter being left.

With the microscope, the cerumen exhibits oily globules, mucous corpuscles, epithelial scales, and an amorphous granular matter.

106. AMNIOTIC FLUID.—This is turbid, yellowish and alkaline, coagulated by heat, nitric acid, and slightly by acetic acid. Its spec. grav. is about 1008, yielding from 1 to 3 per cent. of solids. Bichloride of mercury causes a precipitate, which soon becomes of a rose colour. Benzoic acid and urea have been found in the liquid after it had undergone partial decomposition. It contains chloride of sodium, sulphate and carbonate of soda, sulphate of lime, with traces of salts of potash. The microscope detects mucous corpuscles with tessellated and ciliated epithelium.

107. ALLANTOIC FLUID.—This fluid has been examined in animals. Its spec. grav. was found to vary from 1003–1029. On evaporation, a brownish film forms on its surface, which gradually subsides in flakes, and consists of albumen and earthy phosphates. The residue of its evaporation is partly soluble in alcohol; the solution, on evaporation, yields an acid extractive matter and pearly crystals, which are undissolved on treating the mass with water; the latter are composed of allantoin. The fluid also contains chloride of sodium and ammonium, sulphate and phosphate of soda, phosphate of magnesia and lime, with an aqueous extractive matter. It also contains uric acid, and probably urea.

*Allantoin.*—This interesting substance does not occur in the human body. Its preparation from the allantoinic fluid of animals has been described. It may be obtained artificially by gradually adding peroxide of lead to a mixture of uric acid with water nearly raised to the temperature of  $212^{\circ}$ ; as soon as the oxide of lead ceases to be altered in colour, no more is added. The solution is filtered whilst hot, and on evaporation it crystallizes. It may be freed from urea by cold alcohol. It is rather insoluble in water and alcohol. Its formula is  $C^8 H^5 N^4 O^5 + HO$ .

*Microscop. char.*—It forms colourless rhombic prisms.



108. *Mucus*.—This is a very important secretion from all mucous surfaces, the most obvious purpose of which is to defend them from the contact of irritating matters. In health it is not secreted in large quantity, but in cases of irritation of the secreting surfaces its amount is much increased and its properties considerably altered; the latter are the circumstances under which it is ordinarily presented to our notice.

When moist, it forms a gelatinous, viscid, semitransparent mass, which sinks in water; its degree of inspissation varies; sometimes it is limpid, at others it may be drawn into long threads. When dried, it forms a yellowish mass, which swells in water, re-acquiring its former properties.

*Chem. prop.*—It is insoluble in water, alcohol and æther; reacts as an alkali; is coagulated or corrugated, frequently presenting a fibrous appearance when treated with acetic acid; the latter phenomenon sometimes occurs when it is mixed with much water. When mixed with water and boiled, no coagulum is formed at first, although on long-continued boiling the liquid becomes milky and yields a slight deposit. It yields little or no precipitate with nitric acid, and is perfectly soluble in caustic alkalies. When suspended in water and the poles of a voltaic battery are immersed in it, albumen is liberated at one or both poles. On incineration, it leaves an alkaline ash, containing carbonate and sulphate of soda, chlorides of sodium and potassium, and phosphate of lime.

The composition of mucus is not satisfactorily known; the biliary mucus is the only one which has been examined; this was obtained from ox-bile. It yielded,—C 52·54, H 7·95, N 14·33, O + S 25·18;\* thus approaching the binoxide of proteine in composition, or still more the buffy coat of blood.

Its properties, as stated above, vary according to the membrane by which it is secreted. The chief peculiarities are as follows:—Nasal mucus is remarkable from its great "mucosity," its property of imbibing water and swelling several times after having been dried, and its solubility in acids. It leaves 5·98 per cent. of dry residue on evapora-

\* Dr. Kemp.



tion, and 0.65 per cent. of ash. Intestinal mucus is very viscid; when dry, it is hard and elastic; it swells in water, and if this contains a little alkali it again becomes mucous. It is dissolved by potash and reprecipitated by acids.

Biliary mucus occurs partly in solution (?) and partly in a state of suspension: on filtering the bile, the latter portion is retained, the former passing through the filter, and rendering the bile precipitable by acetic and other acids and alcohol. After treatment with alcohol, it does not become viscid when moistened.

Vesical mucus has been described in Part I. par. 8.

*Microscop. char.*—Mucus exhibits corpuscles (Pl. IV. fig. 18 *a*, and 19 *b*) which resemble those of pus, but are not so readily acted upon by acids, yielding generally a single nucleus only, and that much larger than in the globules of pus; it also contains granules of various sizes (fig. 19 *c*), some of them being mere molecules, others as large as the nuclei of the globules of pus; epithelial scales, and occasionally a fibrous structure are present (fig. 19 *d*;) the fibres of the latter appear composed of very minute granules. In the centre of many of the epithelial scales, large oval granular corpuscles are visible (fig. 18;) they cannot however be mistaken for the true corpuscles of mucus, as they are unacted upon by acetic acid.

109. In disease, the mucus becomes materially altered in quantity and composition; in some cases it contains less solid matter than usual, but a very large relative proportion of saline matter to the dry extract; in others, this increase is not present. The peculiar muco-purulent secretion will be noticed presently; this is almost constantly present in the latter stages of pulmonary diseases; in the secretions of other diseased membranes this peculiar secretion is more rarely observed. Diseased mucus is sometimes acid, and contains various abnormal constituents, such as true pus, blood-corpuscles, abundance of epithelial cells, fatty globules, portions of tuberculous matter, and even of the pulmonary structure itself. Vegetable organizations, somewhat resembling the torulæ occurring in diabetic urine, are also sometimes found. Particles of starch have been found imbedded in masses of mucus; white specks of this kind must not be confounded with those formed of tubercle.

Tubercles, when examined with the microscope, exhibit aggregations of minute amorphous granules, which have vascular (?) fibres running through them, occasionally also minute fatty globules. There is no peculiar tubercle-globule.\* If they have commenced to soften, lymph- or pus-corpuscles are intermixed with the granular substance. They are soluble in acetic acid and ammonia. The peculiar tubercle-globules described by Gruby are supposed by Simon to be particles of starch derived from the food. They might readily be distinguished by a little solution of iodine, or the polariscope.

When subjected to proximate analysis, tubercle yields a small quantity of fatty matter containing cholesterine and cerebrie acid; a substance precipitable by acetic acid and forming a scum when heated, like caseine; albumen, and a residue insoluble in water, somewhat resembling fibrine; also salts.

On organic analysis, it presents no constant composition, as this varies according to the source from which it is derived.

From the lungs it yielded,—carbon, 53·888; hydrogen, 7·112; nitrogen, 17·237; and oxygen, 21·767; corresponding to the formula  $C^{3.5} H^{2.9} N^5 O^{1.1}$ .

*Fluids secreted by Serous Membranes.*—In the healthy state the quantity of fluid secreted by these membranes is extremely small, and we have no opportunity of examining it. Probably the nearest approach to the natural state of the fluid is that which is frequently found after death in the ventricles of the brain, or between the membranes of the spinal cord.

The former is limpid, almost colourless, having a spec. grav. of about 1008, containing no fibrine. The ordinary tests for albumen cause slight precipitates, but in all probability the small quantity of that substance thus indicated is derived from the passage of the fluid over the cut surface of the brain or its blood-vessels. It usually has the properties of diluted serum of the blood. Berzelius found it composed of—

\* Hasse describes bean-shaped or serrated cells, some smaller, others larger than pus-cells, and somewhat flattened.

Albumen . . . . .	0·166
Alcoholic extractive, with soda . . . . .	0·232
Alkaline chlorides . . . . .	0·709
Soda . . . . .	0·028
Animal matter, insoluble in alcohol . . . . .	0·026
Earthy phosphates . . . . .	0·009
Water . . . . .	98·830

Mulder found also fatty matter and alkaline sulphate in it.

*From the Cavity of the Pleuræ.*—These fluids are highly interesting, but have been very imperfectly examined. They vary considerably in appearance and composition, being sometimes serous, and forming a coagulum after removal from the chest during life, at others partially or completely purulent.

*Peritonæal Fluids.*—These are usually of high specific gravity, containing albumen abundantly, but not differing in the nature of their constituents from other serous fluids.\*

*Ovarian Fluids.*—These differ remarkably in their properties, sometimes being quite limpid, and at others dark-coloured, and so thick and gelatinous as to obstruct the canal of the instrument by which they are removed. The animal matter which they contain is in many cases quite peculiar, being exceedingly viscid, and of a brownish or bluish colour; it is probably some modification of proteine. The fluids are slightly alkaline, coagulable by heat and nitric acid; the precipitate with the latter is frequently yellow. Their constituents do not differ, with the above exception, from those of the blood, except that they contain no alkaline phosphate, or at least an exceedingly minute quantity only.

*Serous Fluids from the Tunica Vaginalis.*—These much resemble some of those fluids found in other serous sacs. They contain however more fatty matter, are usually yellowish, slightly opaque and alkaline, yielding albumen copiously. The remarkable fact, that when the fluid of

\* Marchand found one composed of,—albumen, 2·38; urea, 0·42; carbonate of soda, 0·21; chloride of sodium, 0·82; phosphate of soda, with traces of sulphate, 0·06; siliceous matter and loss, 0·89; water, 95·22.

hydrocele is mixed with the serum of the blood, or digested with the deposit which subsides from an admixture of blood with water immediately after its removal, a coagulum is formed, has been pointed out by Dr. Buchanan. The cause of this phenomenon and the nature of the coagulum are unknown.

The fluids of serous cavities frequently contain urea, blood-corpuscles and crystals of cholesterine, the latter floating on their surface. They may be analysed in the same manner as the serum of the blood, but particular attention should be paid to the properties of the various compounds which they contain. When examined microscopically, globules of various kinds are perceived, some much resembling those of mucus; organic granules, with blood-corpuscles, spermatozoa and crystals of cholesterine. Sometimes numerous pus-globules are visible; these are, however, in general not so perfect as in true pus, being frequently disintegrated, or partially so.

110. Pus.—Healthy pus is a yellowish, opaque, neutral fluid which is coagulated by heat, alcohol and nitric acid, the globules being entangled in the coagulum. Its spec. grav. is about 1030. When mixed with water it is precipitated by acetic acid; this does not however always occur. Caustic potash converts it into a uniform, tenacious, mucous mass, in which the addition of water or of acids causes a precipitate. Ammonia acts much in the same way as potash. When pus is mixed with alcohol, and the coagulum washed with that liquid, water subsequently added dissolves a substance which was considered as peculiar to pus, and was called pyine; Mulder states that it is tritoxide of proteine. It agrees with that substance in all the properties which have been detailed (l. c,  $\beta$ .) It is moreover soluble in dilute alcohol, and yields precipitates with dilute muriatic and sulphuric acid and alum, which are redissolved by excess; acetic acid causes a precipitate not soluble in excess. In addition to albumen and tritoxide of proteine, pus contains cholesterine, stearine, oleine, oleate of soda, alkaline chlorides, carbonates, sulphates and phosphates, as also earthy phosphates and oxide of iron; the latter is probably derived from an admixture of blood. The quantitative analysis of pus differ so much from each

other that I shall not detail them. The amount of solids is about 10–15 per cent. The action of neutral salts, as chloride of sodium or ammonium, &c., upon pus is very remarkable. The corpuscles lose their diffusibility through water, and form a large tenacious mucoid mass, which sometimes assumes the appearance of beautiful delicate membranes; it is corrugated or coagulated by acetic acid, as also by nitric acid, and when washed with water the whole of the saline matter is not removed. When examined with the microscope the substance still more resembles mucus than in its chemical properties, being composed of the mucous corpuscles, which are but little affected by acetic acid, and the granular base consisting of irregular molecules.

*Microscop. char.*—Pus contains a large number of corpuscles, to which its opacity and colour are entirely due. They are spherical, granulated on the surface, contain nuclei varying in number from one to four or five, and within these nucleoli (Pl. IV. fig. 25.) The cause of the granular aspect of their surface, which we also find in the lymph and mucus-corpuscles, is obscure. On treatment with acetic acid the external portions of the corpuscles are dissolved, the nuclei being left; these are generally two or three in number. In addition to these, others, less numerous and smaller, are present, which are suspended in the liquid; these are not granulated on the surface. There does not appear to be any essential difference between lymph-corpuscles, the colourless corpuscles of the blood, exudation-corpuscles, those in mucus, those of pus and the proper (?) chyle-corpuscles.

It is thus perceived that pus is composed of two distinct parts; one of which is liquid, the other consisting of minute cells or globules, and both these are essential to the constitution of true pus. If attention be paid to this fact there will be no difficulty in distinguishing pus from mucus. It frequently happens, however, that we meet with an excreted substance which does not yield these two constituents, but still has the general purulent appearance; it contains the granular corpuscles in abundance, these give it the peculiar colour, but the vehicle in which these are suspended is not albumen, or if any of this substance be present it is but a



trace. Mucus here occupies the place of the true purulent albuminous vehicle; the limpidity of pus being exchanged for viscosity and tenacity. Hence also the substance frequently floats in water, as we sometimes find with mucus, especially that from the lungs, its viscosity enabling it to confine small quantities of air which are sufficient to render its spec. grav. less than that of water; moreover it cannot be mixed with or diffused through water like pus.

In some cases the purulent matter is much more fluid, containing few or no granular corpuscles, but numerous red corpuscles of the blood or a solution of their colouring matter; the fluid is generally at the same time fœtid, ammoniacal, and contains sulphuretted hydrogen.

In chronic abscesses the character of the purulent matter is frequently most materially changed, no pus-corpuscles can be detected, but the whole mass appears milky and is composed of innumerable irregular granules of various sizes, none so large as the pus-corpuscles, and none containing nuclei; numerous fatty globules and plates of cholesterine are also present, the albuminous vehicle remaining the same.

111. The following is a general method for analysing various concretions:—

*a.* The substance is powdered, weighed and thoroughly dried, again weighed and extracted with æther, which removes fatty substances. The powder is then exhausted with alcohol, and the substances removed are separately examined.

*b.* The next proceeding must be varied according to the nature of the calculus; if composed principally of phosphates it is exhausted with boiling water; dissolved in muriatic or nitric acid, the solution treated with excess of ammonia, which precipitates phosphate of lime and magnesia, oxalate of ammonia subsequently precipitates the lime which was not in combination with phosphoric acid, and phosphate of soda mixed with free ammonia precipitates the remaining magnesia. This process is not perfectly accurate, as the muriate of ammonia formed retains a portion of the phosphate of lime in solution, so that on subsequently precipitating with oxalate of ammonia the lime separated is



partly derived from the decomposed phosphate. It may be modified by treating the acid solution with ammonia until a very slight precipitate is occasioned, dissolving this in a little acetic acid, then precipitating the lime with oxalate of ammonia, and the magnesia subsequently by ammonia. These precipitates may all contain animal matters, which are destroyed by incineration.

c. A third process is to precipitate the phosphoric acid in combination with iron, as in 34  $\epsilon$ , subsequently the lime by oxalate of ammonia, and the magnesia by ammonia and phosphate of soda.

d. If the substance consists of carbonate or oxalate of lime it is treated with caustic potash; this dissolves animal matter, uric acid, &c.; dissolved in nitric or muriatic acid, treated with excess of ammonia to precipitate the oxalate and any phosphate,\* and the lime separated by oxalate of ammonia.

e. If it consists principally of uric acid, urates, &c. The portion dissolved by water may consist of the urates of potash, soda, ammonia, lime and magnesia, small quantities of phosphates and animal matters. If the solution be evaporated almost to dryness, the urates are deposited, they may be decomposed by muriatic acid and the bases estimated. The portion undissolved by water is treated with dilute solution of potash, and the solution precipitated by acetic acid in considerable excess; the precipitate consists of uric acid. The solution is evaporated until the odour of acetic acid disappears, then treated with water, which leaves albumen, and mucus undissolved. The solution in water may be tested for animal matters with infusion of galls, bichloride of mercury, chloride of tin, &c.

112. CONCRETIONS FROM THE AIR-PASSAGES.—These usually consist of a small quantity of animal matter with phosphate and carbonate of lime and a little magnesia. I found in one, animal matter (mucus with a little blood) 12.5, phosphate of lime 76.35, and carbonate of lime 10.47; it was perfectly structureless.

\* These may be separated by heating to redness, dissolving in muriatic acid, and precipitating the phosphate by ammonia.

113. FROM THE PROSTATE GLAND.—These have usually the same general composition as the above, the principal constituent being the phosphate of lime.

114. GOUT STONES.—These are earthy-looking bodies, consisting principally of urate of soda and cellular tissue. They also contain a little chloride of sodium, sometimes urate of lime and potash. The urates of soda, potash and lime, are soluble in boiling water, the organic substance remains undissolved. Wurzer obtained uric acid 20·0, soda 20·0, lime 10·0, chloride of sodium 18·0, chloride of potassium 2·2, animal matter 19·5, and water 10·3. They may be analysed as in 6.

115. BONES may be analysed according to the methods given in 1, 2 and 3. They consist principally of gelatine, phosphate and carbonate of lime, carbonate of magnesia, fluoride of calcium, sometimes a little oxide of iron and magnesia. After incineration sulphate and carbonate of soda and chloride of sodium are found in the ash. The two former are derived from the combustion of the organic matter.

To analyse the bones they should be separated as perfectly as possible from the periosteum and marrow, dried at a temperature of  $248^{\circ}$ – $266^{\circ}$ , so as to drive off the water; exhausted with æther to remove the fat, incinerated to destroy the organic matters, the soluble salts extracted by boiling water, and the residue treated as above (112, *b*.) The fluoride of calcium is estimated according to 36.

Marchand obtained from the femur,—

Cartilage . . . . .	32·25
Vessels . . . . .	1·01
Basic phosphate of lime . . . . .	52·26
Fluoride of calcium . . . . .	1·00
Carbonate of lime . . . . .	10·21
Phosphate of magnesia . . . . .	1·05
Soda . . . . .	0·92
Chloride of sodium . . . . .	0·25
Oxide of iron, manganese and loss . . . . .	1·05
	<hr/>
	100·00

The magnesia probably exists in the bones as a car-

bonate, being converted into phosphate during the incineration.

The relative proportion of inorganic matters is not the same in all bones.

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In the first part of this work, a general method for analysing the urine was detailed ; a process will now be given which is adapted to any fluid that may be presented for examination :—

116. The first step is to ascertain its physical appearance. This, with the naked eye, is readily accomplished, and the result should be carefully noted. The leading points are the colour, transparency and aspect of solid or semi-solid substances, which are either suspended in it or constitute a deposit. The colour of animal fluids is usually either whitish, yellowish, red, reddish or greenish-brown. The whitish colour generally depends upon the presence of minute colourless, or nearly so, particles, such as the globules of milk, the molecules of the chyle, or the minute granules of the chronic abscess. The yellowish colour either arises from fatty matter, a very small quantity of the colouring matter of the blood or of the bile. The red colour depends either upon the blood or vegetable colouring matters. The former is distinguished as described in Part I. p. 37 ; the latter in Part I. p. 40. The reddish or greenish-brown generally arises from the colouring matter of the bile mixed with that of the blood ; sometimes from the former alone. The detection of the biliary colouring matter is described at pp. 122 and 140. Examination of the solid parts with the microscope completes this part of the process. They are either amorphous, crystalline, or otherwise structural. The amorphous are composed of distinct and united particles ; the former consist of either the organic granules which pervade all animal fluids, the lithates of ammonia or soda (Part I. p. 32,) the molecular base of the chyle (p. 129,) a finely-divided proteine substance (p. 124,)

and carbonate or phosphate of lime (Part I. pp. 35, 44.) Of these amorphous sediments the second and third are the smallest, although they all are exceedingly minute; the organic granules are diffused, of various sizes and somewhat translucent; and the lithates are usually coloured. The united granules are found in precipitated proteine compounds, disaggregated pus-globules and mucus; in the latter they are closely and evenly crowded; in the disaggregated pus-globules they are combined into small compound globules. But the microscopic appearance of these substances is not characteristic. The crystalline substances are readily distinguished by their peculiar forms; all such as are found in animal fluids are figured in the four Plates. Those most commonly occurring are the ammonio-magnesian phosphate, cholesterine, uric acid and oxalate of lime; they are readily recognised with the microscope. The spherical globules are generally composed of fatty matter. The third kind is generally composed of minute cells, which are spherical and granular on the surface in those from pus, mucus, chyle and lymph; they yield nuclei when treated with acetic acid, especially those from lymph and pus, and the differences between them are very slight and inconstant. When from the blood, they are characterized as at p. 105; when composed of epithelium, they are large, oblong and irregular, the surfaces being more finely granular; they also contain a single large nucleus, which with the cell-wall is insoluble in acetic acid. In some fluids we find fibres of fibrine or mucus, infusoria and ferment-plants.

117. The next point is the separation of the solid from the fluid parts. This may be frequently accomplished by placing the fluid aside in a tall glass vessel, and at the end of some hours decanting the upper portions. Filtration is the most perfect method, when it can be effected; in many it cannot. If this be the case, dilution of the fluid with water will sometimes enable us to succeed; at others, the admixture of saline solutions, as those of sulphate of soda or chloride of sodium (p. 124.) It is best to filter first through linen or coarse paper, subsequently using finer.

118. When the clear fluid is separated, its acidity or alkalinity should be noticed. This is readily effected (p. 59.)

The amount of free acid may be ascertained by carefully neutralizing a weighed portion of the fluid with a dilute solution of ammonia or carbonate of soda, the exact strength of which is previously known. It may be added from a graduated tube, agitating the mixture each time until it is just commencing to react as an alkali upon the test-paper. Thus the quantity of the solution used and its strength being known, the amount of the acid saturated is easily found. The amount of alkali is ascertained in exactly the same manner, substituting a dilute acid of known strength for the alkaline solution. The acid reaction is generally derived from either acetic, lactic or butyric acids, or from acid salts, as superphosphates. The alkaline reaction generally arises from either carbonate of soda or carbonate of ammonia. The method of recognising these acids and bases have been described in their respective places.

119. The next stage is the qualitative analysis of the fluid. The ordinary substances which occur are the following:—

1. Proteine compounds { Caseine.  
Fibrine.  
Albumen, globuline.  
Oxides of proteine.
2. Fatty matters { Acid :—Oleic, margaric, stearic.  
Neutral :—Oleine, margarine, stearine, buty-  
rine, cholesterine and glycerine.
3. Sugar :—Lactic diabetic.
4. Bilic acid, or the products of its decomposition.
5. Urea, allantoin.
6. Colouring matters :—Hæmatine, cholepyrrhine.
7. Acids { Organic :—Acetic, lactic, butyric, hippuric, uric,  
benzoic.  
Inorganic :—Sulphuric, phosphoric, muriatic.
8. Bases { Volatile :—Ammonia.  
Fixed :—Soda, potash, lime, magnesia, oxide of  
iron.

120. If any semi-solid matter is present as a deposit, if it is firm and rendered more transparent by acetic acid, it is fibrine; if it is rather coagulated by the acid, rendered softer, and exhibits under the microscope mucus-corpuscles and epithelial scales, it is mucus.

121. A small quantity of the fluid is next heated to the boiling-point. If it is now found acid, and no precipitate falls, no albumen is probably present; if it is acid, and a precipitate does fall, albumen is present. If it is neutral or slightly alkaline, a very small quantity of a dilute acid should be added, so as to neutralize it exactly; if no precipitate falls, no albumen is present. If a precipitate has formed, it should be allowed to subside; if it is red or reddish-brown, and the liquid is almost decolorized, albumine and hæmatine are present.

122. Acetic acid is then added, either to another portion of the fluid, or to that poured off from the deposit; if a precipitate fall, caseine is probably present. The suspicion is confirmed by the precipitate being soluble in excess of the acid, and its being amorphous. If it is not soluble in acetic acid, that modification of tritoxide of proteine called pyine is present.

123. If, after the ebullition of the fluid and separation of the albumen, alcohol cause a precipitate, one of the oxides of proteine is present; if the precipitate be soluble in the dilute mineral and acetic acids, and the solution be precipitated by ferrocyanide of potassium, it is the binoxide; if not, the tritoxide.

124. If allantoin, uric or hippuric acids be suspected to exist in the fluid, a portion should be boiled, filtered and evaporated to one-fourth; if allantoin be present, it crystallizes (Plate IV. fig. 28.) It is soluble with difficulty in cold water, and also in alcohol. Another portion is treated with a drop or two of muriatic acid, and gently evaporated. If long prisms separate, hippuric acid is probably present; if minute rhombs subside, lithic acid is present. If the crystals are thin and very insoluble in water, they are probably composed of benzoic acid. Each precipitate must be tested as regards the reactions for these acids (Part I. pp. 26 and 42, and Part II. 87.)

125. If, on the addition of nitric or muriatic acid to the fluid, a green precipitate falls, or the fluid acquires a green tinge, or passes through the series of tints (p. 140,) the colouring matter of the bile is present.

126. Bilic acid, or the proper biliary matter, may be detected as at p. 122.



127. After evaporating a portion of the fluid to dryness and exhausting it with æther, the residue of the evaporation of the æther may be tested as at pp. 74 and 83, to separate the fatty matters.

128. Urea may be detected as at p. 123. Sugar is detected either by Trommer's test or fermentation, and the presence of the *torulæ*.

129. The inorganic constituents may be best detected as at Part I. p. 28, and estimated as in the analysis of the serum of the blood (p. 118.)

## APPENDIX.

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1. It has been recently found that Becquerel's table for ascertaining the amount of solids in urine gives too low an estimate. Dr. Christison has proposed a more accurate proportion, which is found by multiplying the difference between the specific gravity of the urine and 1000 by 2·33; the result gives the amount of solids in 1000 grs. Inasmuch as these tables are only intended to afford a ready means of roughly estimating the amount of solids passed *per diem*, they sufficiently answer the purpose; but the experimenter will frequently find, on testing them by evaporating the urine to dryness, and thus directly estimating the solid residue, that his results will at one time agree with one table, at another with a different one; this arises from the facility with which some of the constituents of the urine are decomposed, especially the urea.

2. Scherer has recently examined the extractives and colouring matter of the urine. He considers that what has hitherto been considered the extractive of the urine is a peculiar substance, which is analogous to the animal colouring matters. He finds that its elementary composition varies. It may be precipitated by various chemical substances, especially acids and both acetates of lead; but its composition varies in the urine of different individuals. He found its composition thus:—C 58·43, H 5·16, N 8·83, O 27·58. It was obtained by first treating the urine with nitrate of baryta, and then with the neutral and basic acetates of lead. The precipitate was washed, warmed with muriatic acid and alcohol, filtered when cold, then evaporated and washed with water. When dissolved in water with a little potash, and then treated with nitric acid, it

yields the alterations in colour which are characteristic of the biliary colouring matter.

3. The composition of urea per cent. is as follows:—C 20·02, H 6·71, N 46·73, O 26·54. An excellent process for estimating the quantity of urea is this:—A weighed quantity of urine (90–100 grs.) is treated with basic acetate of lead until it ceases to yield any further precipitate; the mixture is set aside, filtered, and sulphuretted hydrogen passed through the solution to separate any excess of lead; the fluid is evaporated, mixed with sulphuric acid in the proportion of about half the weight of the urine used; the mixture is then heated over a spirit-lamp or sand-bath at a heat of about  $380^{\circ}$  until the evolution of carbonic acid commences, the vessel is then covered and the heat continued until the evolution of carbonic acid ceases, the temperature being kept below  $572^{\circ}$ . The carbonaceous residue is then mixed with water, the solution filtered, and evaporated until almost all the water has passed off. A small quantity of muriatic acid is then added to the residue, and a sufficient quantity of chloride of platinum mixed with alcohol and æther, to render the solution of a yellow colour. The whole is set aside, the precipitate separated by filtration, washed with alcohol and a little æther, dried and heated to redness; the residue is then treated with boiling dilute muriatic acid, the solution filtered, the pure platinum then dried and heated to redness. This amount of platinum corresponds to the ammonio-chloride of platinum formed from the ammonia salts present in the urine, with that formed from the decomposition of the urea; and the potassio-chloride of platinum formed from the decomposition of the potash salts in the urine. The amount of platinum corresponding to the ammonia and potash salts existing in another portion of the same urine must be estimated by a separate experiment and deducted from the above total quantity; it is variable. M. Heintz found it between 0·1 and 1·16 per cent. The same chemist found that the extractives of the urine yielded as much ammonia as would correspond to 0·018 per cent. of urea; this quantity is however so small, that it may be overlooked. 100 parts of ammonio-chloride of platinum are equal to 13·4498 of urea; also, 100 parts of pure platinum are equal to 30·401 of urea.

4. The occurrence of lactic acid in the urine has been carefully examined by numerous observers; they agree in the conclusion that it does not happen. A peculiar substance has been shown to exist in this fluid, which in some of its properties resembles lactic acid; especially in forming a crystalline compound with oxide of zinc, which assumes the form of four-sided prisms; these are however terminated by oblique terminal surfaces, and the substance contains a large quantity of nitrogen. It is most probable that this compound has been mistaken for the lactate of zinc.

5. Liebig has shown that hippuric acid is a constant ingredient in urine. It is best separated by evaporating the fluid until most of the salts are deposited, adding strong alcohol and applying heat. The clear solution is then to be poured off, evaporated nearly to dryness, the residue redissolved in hot water, the urea decomposed by passing a current of chlorine through the solution, a small quantity of muriatic acid added, and the mixture concentrated by gentle evaporation. The hippuric acid then crystallizes.

6. The composition of cystic oxide per cent. is—C 30·01, H 5·10, N 11·60, O 28·38, S 25·51.

7. The composition of diabetic sugar per cent. is—C 40·156, H 6·705, O 53·139.

8. Of xanthic oxide,—C 39·28, H 2·95, N 36·35, O 21·42.

9. Of uric acid,—C 36·083, H 2·441, N 33·361, O 28·126.

10. Simon has pointed out the existence of some curious minute bodies in the urine under certain circumstances. They form cylindrical sacs, having distinct walls, and are of such a diameter as to permit mucus-corpuscles to move freely within them, and are either completely or partially filled with a granular matter; also elongated masses, having the form of these cylinders, but without any distinct parietes, and evidently the contents of the cylinders. They are probably composed of a fibrinous exudation from the walls of the urinary tubules. They are well seen with a power of 300, or even less, and are found in cases where the urine is albuminous, or in cases of irritation of the kidneys, in which this occurs at a subsequent period.

11. By filtering the saliva and treating it with 5–6 times its weight of absolute alcohol, M. Mialhe has obtained a

remarkable substance, which closely resembles diastase, and which he believes to be identical with it. It exerts exactly the same action upon starch as vegetable diastase. It is precipitated by the alcohol, and should be collected on a filter, and whilst still moist should be placed upon a plate of glass, and dried in a current of air at  $104^{\circ}$ – $122^{\circ}$  F. Nothing is known of its composition. Is it an oxide of proteine?

12. The amount of sulphocyanic acid in the saliva is best estimated by evaporating a weighed portion of the saliva to dryness, exhausting the residue with alcohol, evaporating the alcoholic solution, dissolving the remainder in water, raising the solution to the boiling-point, and then adding a mixture of chlorate of potash and muriatic acid. The sulphur is thus oxidized, and the sulphuric acid formed is precipitated by a soluble salt of baryta. 100 parts of sulphate of baryta correspond to 25.11 of sulphocyanogen, or 41.91 sulphocyanide of potassium.\*

13. In preserving microscopic objects, perhaps the best substance for cementing the thin glass to the slide is black Japan varnish; although, provided the walls of the cell be made on the slide, and allowed to dry thoroughly before the thin glass is applied, the kind of cement is not of great consequence.

14. The mode of drying substances in a water-bath is well known. The substance, placed in a crucible, should be kept in the bath until the total weight ceases to diminish.

15. It is also perhaps unnecessary to state, that previous to pouring a liquid upon a filter, the filter should be moistened with either water, alcohol or æther, according to the nature of the fluid to be separated from the precipitate. In washing precipitates, the process should be continued until a drop of the liquid from the beak of the funnel leaves no, or an inappreciable amount of residue on evaporation.

16. A few filters, which have been perfectly dried at  $212^{\circ}$ , should be kept, so as to be at hand when precipitates which must be dried at  $212^{\circ}$  are required; after the drying of the filter and the precipitate together, by deducting the weight of the former from the total weight, that of the precipitate is left.

\* Pettenkofer.





Plate 3.

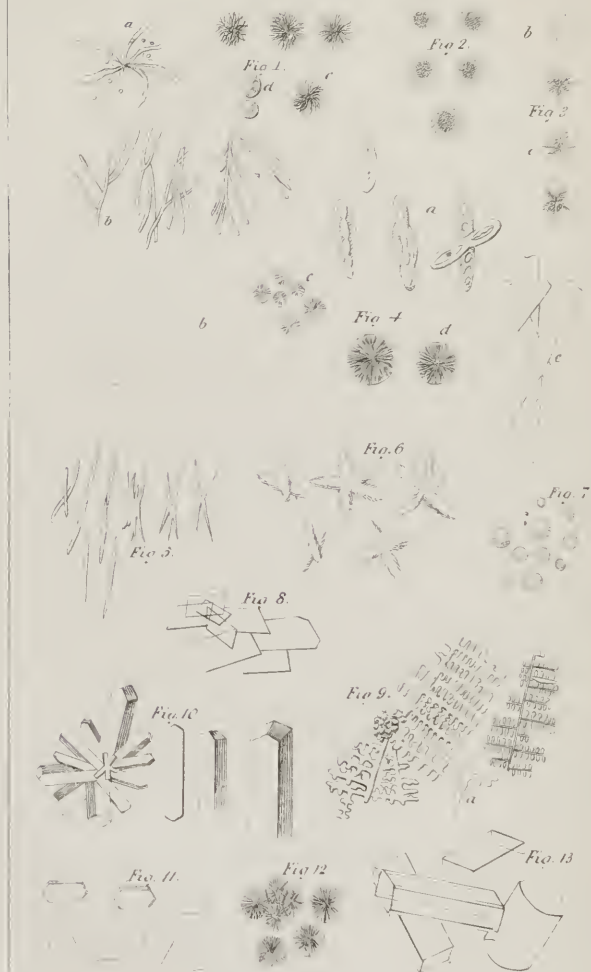


Plate 4.





### DESCRIPTION OF PLATE III.

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- Fig. 1. Margarine from human fat. *a* and *b*, minute branched needles; *c*, tufts composed of needles more rapidly formed; *d*, drops of oleine. 150 diameters.
2. Stearine. It is rarely found to exhibit any distinctly crystalline form; that figured however sometimes occurs.
3. Also margarine, more highly magnified. *a*, tufts composed of ramified needles; *b*, the same, more highly magnified.
4. Sebacic acid. *a*, prismatic form; *b*, thin plates; *c*, minute tufts; *d*, the same, more highly magnified. These forms are found in the acid crystallized for the first time from a hot aqueous solution of the products of distillation of a fat containing oleine; *e*, the same, recrystallized and pure, exceedingly thin elongated laminæ.
5. Margaric acid. 150 diameters. These crystals somewhat resemble those of margarine.
6. Stearic acid. 150 diameters.
7. Oleine.
8. Cholesterine. Thin rhomboidal plates, the angles occasionally truncated.
9. Muriate of ammonia. The form *a* approaches very near the dagger-shaped crystal of chloride of sodium and urea.
10. Lactate of zinc.
11. Acetate of zinc. These are very thin plates.
12. Carbonate of lime. See p. 100, note.
13. Ammonio-phosphate of soda from urine by evaporation. After Simon.

## DESCRIPTION OF PLATE IV.

- Fig. 14. Blood. *a* and *b*, coloured corpuscles ; *a*, as ordinarily seen ; *b*, lateral view, when turning over ; *c*, colourless corpuscles ; *d*, after treatment with acetic acid, exhibiting nuclei.
15. Blood during coagulation; the coloured corpuscles forming areolar spaces by the adhesion of their plane surfaces, the colourless corpuscles remaining distinct.
  16. Blood before coagulation commences. Seen with a much lower power than in 14.
  17. Oxalate of soda. *a*, dumb-bell form ; *b*, prisms ; *c*, tufts.
  18. Epithelial scales and mucous corpuscles.
  19. Mucus (nasal.) *a*, epithelium ; *b*, mucous corpuscles ; *c*, granular matter ; *d*, fibrous appearance. Less highly magnified than in the last figure.
  20. Nitrate of urea, crystallized from blood in Bright's disease.
  21. Nitrate of soda, from an aqueous solution of the alcoholic extract of blood.
  22. Tartrate of lime.
  23. Milk-sugar. *a*, tufts (after Vogel) ; *b*, prisms.
  24. Benzoic acid. *a*, by sublimation ; *b*, by crystallization. From cow's urine.
  25. Corpuscles of pus. *a*, ordinary ; *b*, after the addition of acetic acid.
  26. Fatty globules from the colostrum, somewhat resembling the globular masses in sour milk.
  27. Bitartrate of potash.
  28. Allantoin.
  29. Semen, containing crystals of phosphate of lime.

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\* \* The figures to which the Roman character is affixed refer to Part I.

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THE END.

ON THE  
ANALYSIS  
OF THE  
BLOOD AND URINE,  
IN  
HEALTH AND DISEASE;  
AND ON  
THE TREATMENT OF URINARY DISEASES.

✓  
BY

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FROM THE SECOND LONDON EDITION.

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PHILADELPHIA:  
LEA & BLANCHARD.

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1848.



TO  
RICHARD BRIGHT, M.D., F.R.S.,  
&c. &c.

PHYSICIAN EXTRAORDINARY TO THE QUEEN,

CONSULTING PHYSICIAN TO GUY'S HOSPITAL, PRESIDENT OF THE HUN-  
TERIAN SOCIETY, ETC. ETC.

MY DEAR SIR,

It would have been a pleasure to me to dedicate this work to you, if only to mark my admiration for those discoveries which make your name as a philosopher familiar to the practitioners of medicine throughout the civilised world. I have, however, an additional gratification in availing myself of this opportunity of expressing my gratitude for the kind encouragement received from you when, as a mere boy, I first entered on the study of pathological chemistry. The confidence you have reposed in my results and observations, at more advanced periods of my professional career, I shall ever regard as a flattering assurance that my time has not been ill spent; and though well aware that I have effected very little by my labours, still, had it not been for your friendly aid and council, that little must inevitably have been far less than it is.

That your kind word and noble example have not produced a better result is felt with regret, by

Yours, gratefully and attached,

G. OWEN REES.

59, Guildford Street, Russell Square,  
October 1, 1845.

B





## PREFACE TO THE FIRST EDITION.

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THE increased desire for a more intimate acquaintance with animal chemistry, which has lately been evinced by the medical profession, induces me to present this little work to public notice.

The more philosophical methods of investigation at present adopted to ascertain the diseased conditions of the living system have forced a new branch of inquiry upon the attention of the student ; while the further advanced labours in the medical profession feel the necessity of informing themselves on a subject which becomes important (to them at least) were it only as a shield against the exposure which might occur from the more perfect knowledge of a rising generation.

It has been my object in this work, to exhibit a concise view of those plans of analysis which may be performed simply, usefully, and at a small expense ; requiring for their execution care and patience rather than skill and perfection in manipulation.

I have avoided as much as possible those formal methods of description which have frequently disheartened the beginner from even reading a process, much more putting it to practice. If any such feeling be entertained by my readers, let me assure them that it is the reading, and reading only, that perplexes them; and that when once they have commenced the practice of the process, all confusion will pass away, and the facts become clearly and firmly impressed upon their minds.

If the study of this volume should in any way tend to increase the number of those who occupy their leisure hours with the study of animal analysis, as applied to disease, I shall be more than repaid for my slight labours; for I shall feel that I have assisted in directing attention to a subject which, in all probability, is no less rich in discovery than it is neglected and uninvestigated by the great body of the medical profession.

## PREFACE TO THE SECOND EDITION.

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THIS second edition is constructed on the plan of the first, with the addition of an essay on the treatment of urinary diseases. Considerable alterations have been rendered necessary by the advances made in animal chemistry since the first edition was published; but I have avoided, as much as possible, entering into scientific details as foreign to the purpose of the work, which must not be regarded as an elaborated treatise on the blood and urine in all their relations, but simply as a work on proximate animal analysis. Substances of rare occurrence in the blood and urine in disease, or which exist as mere traces, and are not well examined or ascertained in the healthy fluids, are here only slightly noticed; and, for information of a more extended kind, the reader is referred to the works of Berzelius, Lecanu, Denis, Becquerel, and Simon. From the latter author I have made extracts in the Appendix relating to the analysis of the blood.

My object has been throughout simply to supply to the

medical practitioner the means of analysing blood and urine, and thus to assist him to comprehend and appreciate with more defined ideas the experiments of those animal chemists whose results may have reference to the important subject of humoral pathology.

I have added a microscopical description, and drawings, to that part of the work treating of urinary deposits.





# REESE ON BLOOD & URINE



## DESCRIPTION OF MICROSCOPICAL FIGURES REPRESENTED ON THE PLATE.

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1. Monobasic ammoniaco-magnesian phosphate in prismatic crystals; the forms derived from the right rectangular prism, observed generally in neutral or slightly acid urine, sometimes also in slightly alkaline urine.
2. Bi-basic ammoniaco-magnesian phosphate, formed in specimens of urine which are strongly alkaline.
3. Lithic acid in various forms, prismatic, rhomboidal, and lozenge-shaped.
4. Lithate of magnesia in prismatic crystals. When occurring in groups or tufts this is often mistaken for lithate of lime, but may be distinguished by the crystals being truncated, while those of lithate of lime have an acicular form.
5. Lithates of ammonia and other bases.
6. Lithate of lime in tufts and acicular crystals.
7. Cystine in hexagonal plates.
8. Hippuric acid in four-sided prisms.
9. Oxalate of lime in octahedral crystals and other forms.\*
10. Pus corpuscles.
11. Epithelium.
12. Mucons corpuscles, with tubes of albuminous matter; first described by Simon as existing in albuminous urine.
13. Milk corpuscles.
14. Seminal animalculæ, occasionally observed in the urine, sometimes in connection with traces of albumen.
15. Torulæ, observed in diabetic urine during fermentation.
16. Blood corpuscles. The largest and lined figure represents one of the fibrinous corpuscles as seen in the blood. The red corpuscles are represented thicker than when viewed floating in liquor sanguinis, having undergone endosmotic change by contact with the urine.

\* As described by Dr. Bird.

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## INTRODUCTION.

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BEFORE I enter on the description of processes, I feel it necessary to offer a few observations on the cautions to be observed in the more important steps of manipulation. It may also be proper to describe the uses of one or two contrivances to which analytical chemistry is pre-eminently indebted, and without which it is difficult to conceive how any degree of perfection could have been attained in the prosecution of analysis. I shall proceed at once, therefore, to a description of the following operations, viz. Evaporation, Filtration, and Incineration; concluding with a few observations on the precautions which are necessary in weighing fluids and solids.

*Evaporation.* This may be performed at different degrees of heat; and the greatest care should be taken to choose a suitable temperature. Thus, if urine be experimented upon, it is impossible to use a continued heat of  $212^{\circ}$  Fahrenheit, without risking the loss of a portion, at least, of the urea, which is one of its most important constituents. When the serum of blood is experimented upon, a heat of  $212^{\circ}$  is absolutely necessary, for the purpose of rendering the albumen entirely insoluble in boiling water; indeed, it has been stated, that a heat of  $225^{\circ}$  is necessary for that purpose; but this is not the fact, as will be found on experiment, particularly if the serum be thoroughly dried, and then treated, while warm, with water at  $212^{\circ}$ .

*Filtration.*—Considerable care is requisite in performing this operation; fine white bibulous paper should be used, and the filter washed with distilled water before it is applied to the

purposes of analysis. After the fluid we are operating upon may have passed through the filter, it often becomes necessary to perform many ablutions of the filter, in order to wash out from the paper all the fluid for analysis: these washings, are of course, to be added to the first-filtered liquor, and evaporated with it in continuing the examination. When pouring from any vessel into a filter, the lip of such vessel should be kept perfectly dry, otherwise the fluid may, after passing the lip, run backwards to the bottom of the vessel, and thus be lost. Another excellent method of avoiding this evil, consists in applying the side of a glass rod, moistened with distilled water, to the lip of the vessel, and pointing it upon the filter. These may seem trifling circumstances to dilate upon, but persons who are accustomed to manipulation are well aware of the value of such remarks to the uninitiated.

*Incineration.*—Constant attention is necessary in this process, and much tact requisite in placing the crucible in proper positions in order to expedite the dissipation of the carbonaceous matter. The crucible should be somewhat shallow, and of the form of a dish or flat capsule. It should be placed on the top of the flame of the circular-wicked spirit lamp, and with a slight inclination towards one side: this position favours the constant fresh access of air, and assists in dissipating the carbon. The crucible should, of course, be opened immediately that the animal matter is charred; but a loose cover ought to be placed upon it before the salts begin to fuse (as sometimes happens,) in order to prevent the loss which may take place by decrepitation.

The crucible is to be managed by a small pair of forceps with scissor handles, similar to the dressing-forceps used by surgeons.

*Weighing.*—There is, perhaps, no operation in chemistry which demands so much attention as that of weighing: for the substances to be weighed are frequently of a destructive nature, and the balance is more easily injured than any other of the requisites of a laboratory. In weighing animal matters, both

solid and fluid, there is continual danger of moistening the balance-dishes, and thus interfering with the accuracy of the result.

To the student in animal chemistry, I would advise the use of a balance, capable of turning to one-fiftieth of a grain. This should be mounted in a balance lantern, and kept in a dry room. Accuracy is greatly ensured by the habit of weighing by counterpoise, which is by balancing the substance to be weighed, with dry powdered sand (or any other convenient powder); and then, on removing this substance, whose weight is to be ascertained and counterpoising the sand in the balance with the weights, the most accurate result is obtained; for the number of grains, or parts of a grain required, must be identical in weight with the substance removed, before they can produce the same effect, of precisely balancing the sand. By this method all that is wanted in the balance is a suitable degree of delicacy. The necessity for an equality of length in the scale-arms (which is very difficult to procure) is thus obviated, though it is absolutely necessary to the perfect determination of weight by the common method.

The weight of fluids for analysis may be taken by two methods, viz. by balancing them in a bottle the weight of which has been previously ascertained; or by weighing the vessel and fluid together, and then noting the diminution of weight which occurs, when the fluid for analysis is poured out. The former method possesses the advantage of yielding a fixed quantity; for we can pour into the weighed vessel exactly the weight of fluid we wish: but it is necessary always to wash out the weighing vessel with distilled water\* after the weighed fluid is poured out, in order to remove the adherent portions in the bottle, which, of course, were taken into account when the weight was ascertained. By the second method we avoid the necessity of washing out the weighing bottle; for the

\* These washings must, of course, be added to the fluid for analysis, and evaporated with it in pursuing the analysis.



weight we note is just that of the fluid poured out : but then we lose the means of procuring any fixed quantity of fluid which we may desire. This, however, is no great disadvantage, since we can always calculate the proportional quantities in any number of parts we may choose. The former method may sometimes be adopted, the weighing being performed in a dish which may serve also for the evaporation, thus doing away with the necessity of removing the fluid from one vessel to another. The weight of solid animal matters should be taken in an accurately balanced watch-glass, placed upon a curl of paper, which prevents its slipping from the operator ; an inconvenience occasionally very distressing during manipulation, but which may be easily obviated by this simple expedient. Before quitting this subject, I must urge upon the reader the propriety of noting with the greatest care the result of every weighing performed during an analysis.

I shall now proceed to describe the contrivances adopted for procuring that degree of heat which may be requisite for the purposes we have in view, and shall notice some chemical implements eminently useful in the prosecution of animal analysis.

*Water-bath.*—This may be divided into two kinds, viz. the fresh and salt water-bath. The former is formed by floating a dish in water, which is kept at a boiling temperature by means of a lamp or any other steady source of heat. Fluids placed in this floating dish are kept at a temperature approaching that of boiling water ; that is, somewhat below  $212^{\circ}$  Fahrenheit. The salt water-bath is formed in the same manner, excepting that the evaporating dish is floated in a saturated solution of common salt instead of fresh spring water, by which means we can procure a heat of  $225^{\circ}$  Fahrenheit.

*Steam-bath.*—This may be divided also into two kinds, viz. the open and closed. The former is eminently useful in the examination of fluids suspected to contain easily destructible animal principles, and is the one which should always be used, if admissible, in preference to any other sort of bath. It is formed by placing a dish over the steam issuing from a vessel

in which water is kept at a boiling heat; care being taken that the evaporating dish do not touch the vessel of water in any part, but be supported over it by means of a small wooden rack. In this way we obtain a constant heat, which is far below that of boiling water. The closed steam-bath differs from the open, in being formed by a dish which perfectly closes the vessel from which the steam is issuing. It affords a very variable heat, which frequently approaches  $212^{\circ}$  Fahrenheit. The fresh water-bath is generally to be preferred.\*

*Circular-wicked Spirit Lamp.*—This is a somewhat dangerous piece of apparatus in the hands of the beginner. Many of the lamps sold for the purpose of burning spirit, are so constructed as to allow of the reservoir becoming heated and the spirit consequently boiling within so short a time after the wick has been lighted, that we cannot well obtain a sufficiently continued heat for our purposes. From the experience I have had in the use of this instrument, I am inclined, on all occasions when the application of a long continued heat is necessary, to prefer an open fire to a lamp, even when of the best construction.

When an open fire is used our platinum crucible must be placed within a larger one of clay. In this manner we can very easily effect incineration and dissipate carbon from burned animal matters in the process of obtaining fixed salts, and our platinum vessel is kept perfectly clean, being protected from the fuel by the large clay crucible.

In choosing a spirit lamp the great object should be to select that form which shows the least possible connection between the reservoir and the circular wick, and the connection existing should be formed as much as possible of glass or other badly conducting material.

\* There is an excellent arrangement for the water or steam bath, made of brown earthenware, sold at the chemical apparatus warehouses.

I have now to make a few remarks on the necessity of employing pure re-agents. Unless this be carefully attended to, we shall frequently find ourselves in most unpleasant difficulties. I would recommend that no one should use any of his solutions until he has tested their purity for himself. We frequently find that the distilled water of the shops becomes cloudy on the addition of a few drops of the solution of nitrate of silver (indicating the presence of a chloride;) this ought not to be the case, and such water should be discarded as unfit for use.

The ordinary hydrochloric acid of the shops always contains iron in solution, and is frequently admixed with sulphuric acid, as is also the case with the common nitric acid.

These acids should never be used as re-agents in their officinal condition, but always procured (in their perfectly colourless form) from some well-known operative chemist.

The sulphuric acid of the shops contains sulphate of lead in solution, which is easily detected by diluting the acid, when that substance becomes precipitated. Arsenic has likewise been detected in some specimens of this acid, which may be accounted for, by the fact, that a vast quantity of sulphuric acid is made with sulphur procured from arsenical pyrites. In several specimens of sulphuric acid lately examined, I detected arsenic in amount equal to from 20 to 30 grains in the pint. In some instances I detected the presence of selenium in small quantity.

The officinal liquor potassæ should never be used as a re-agent, for it frequently contains lime.

Were I to proceed to show the reasons for avoiding the purchase of officinally prepared solutions, I should far exceed the intentions of this work; I will, therefore, at once conclude, by earnestly entreating the beginner to exercise extreme caution in the selection of reagents.

My reason for especially noticing the impurities of distilled water, the mineral acids, and the liquor potassæ, is that these are the most likely to be purchased as officinally prepared.

I subjoin a list of chemicals, which will be found sufficient for most purposes, in prosecuting the proximate analysis of animal bodies.

Pure sulphuric acid,	} Strong.
hydrochloric acid,	
nitric acid,	
acetic acid,	

These acids should also be kept in a dilute form. One part of strong acid to nine of water is a convenient mixture.

Solution of caustic potassa.

—	ammonia.
—	carbonate of potassa.
—	oxalate of ammonia.
—	bichloride of mercury.
—	acetate of lead.
—	di-acetate of lead.
—	alum.
—	ferro-cyanuret of potassa.
—	tartaric acid.
—	nitrate of silver.
—	chloride of barium.

Tincture of galls.

Sulphuret of iron.\*

Litmus paper, both blue and reddened,†

\* For procuring a stream of sulphuretted hydrogen gas:—This is done by placing the powdered sulphuret in a large phial, and adding sulphuric acid, diluted with three times its bulk of water. The gas which escapes can be conducted to the bottom of the fluid which we wish to act upon, by means of a glass tube, bent twice at right angles; one leg of which must be inserted air-tight into the cork of the phial; and the other (which must be sufficiently long) made to pass to the bottom of the vessel holding the liquid to be subjected to the action of the gas.

† Reddened litmus paper, if well prepared, is an extremely delicate test of alkali, far more so than turmeric paper, which, however, should also be used, as the effect produced upon it by animal solutions (if compared with their effect on reddened litmus) affords a rough, but frequently a useful, test of the degree of alkalinity.

Turmeric paper.

Alcohol—specific gravity .833.

Rectified ether.

The following instruments of analysis, will now render our laboratory pretty complete:—

A platinum crucible, capable of holding about half a fluid ounce.

Platinum foil.

—— wire.

Test tubes and stand.

Watch-glasses.

A blow pipe.

Glass rods.

A spirit lamp.

Test glasses.

Forceps.

A pair of scissors.

Bone spatulas.

Steel spatulas.

Glass funnels.

Wedgewood dishes of various sizes to contain from a quarter to half an ounce.

German China-ware dishes and capsules.

Lamp rack and dish stands.

ON THE  
ANALYSIS  
OF THE  
BLOOD AND URINE.

---

ON THE BLOOD.

As it is impossible for the student thoroughly to understand the principles on which the methods for analysing the blood are founded, or to possess a clear and well defined view of the application of chemistry to the advancement of humoral pathology, unless he become acquainted with the minute physical structure of the blood, I shall, in the first place, proceed to a description of that fluid as it circulates in the vessels, and point out, by reference to its minute anatomy as shown under the microscope, what those parts of its history are requiring the assistance of chemistry for their further development. The student will thus be enabled more completely to understand the nature of the changes occurring during coagulation, and more fully to appreciate the extent to which physical actions occurring in the blood, after removal from the body, and over which we have no control, are capable of affecting the positive value of our results.

He will also be able to appreciate the exact point at which chemical methods of analysis should commence, and beyond which physical division can no longer be practised; and, I trust, will thus be impressed with the absolute necessity of possessing an accurate knowledge of the physical



structure of the blood before he can hope to enter upon its chemistry with advantage.

The blood as it circulates through the vascular system, may be described as made up of a fluid holding in suspension a number of minute organised bodies of a red colour, which so thickly pervade the suspending fluid as to give it to the unassisted eye the appearance of a homogeneous red solution. There are, existing in the blood, besides these red corpuscles, a smaller number of colourless bodies of a different organization, and known by the name of fibrinous corpuscles. In addition to these, we also occasionally remark granules of various sizes thinly scattered through the blood, and which seem to appear in greater numbers a short time after a meal, and at a period when the flow of chyle into the blood has taken place freely. When the blood coagulates, the fluid in which the corpuscles float, and which has been called liquor sanguinis, becomes disintegrated, a solid matter depositing from it, known under the name of fibrin, while its fluid portion, containing the albuminous and saline matters in solution, forms serum. The fibrin as it separates becomes mixed up with the red corpuscles, and the two together make up the mass known as crassamentum, which floats in serum, as is seen in coagulated blood. The white bodies which I have described as floating with the red corpuscles in the liquor sanguinis, are entangled with these latter in the fibrin during coagulation: thus the serum is nothing else than a clear solution of animal matters and salts. When blood is about to coagulate, it is always observed, that before the deposition of fibrin from the liquor sanguinis commences, the corpuscles floating in the blood begin to subside, and leave a thin stratum of liquor sanguinis on the surface. If this be removed by carefully skinning the blood, we obtain pure liquor sanguinis of a pale straw colour, which, when set aside, will separate into fibrin and serum. It was by thus skinning inflamed blood, that Hewson first succeeded in obtaining a fluid capable of coagulation; but he did not carry out this observation on healthy blood; and it was left for Dr. Babington to prove, that healthy blood as it circulates is made up of a homogeneous fluid, containing floating corpuscles, and to this fluid, which he proved to be a solution

of fibrin in serum, Dr. Babington gave the name of liquor sanguinis.\*

When examining the blood, then, under the microscope, we must bear in mind, that, when freshly drawn from a puncture, it is composed of corpuscles floating in a homogeneous fluid, but that if coagulation be allowed to take place, we have the corpuscles floating in serum, or, in other words, in liquor sanguinis deprived of its fibrin, a condition which will materially interfere with the natural appearance of the corpuscles, for reasons which will be at once apparent when the physical properties of those bodies have been described.

The anatomy of the red corpuscles has formed a subject for conjecture and experiment among physiologists for a number of years, and a great diversity of opinion has existed as to their true nature. Some have believed them solid bodies, while others, on the contrary, have believed them of more complex vesicular structure. We are now, however, enabled to speak positively as to their nature, their vesicular structure having been put beyond doubt by late experiments, which have shown that endosmotic currents can be induced through their membrane, and that the corpuscles, as seen under the microscope, can either be emptied or filled accordingly as we mix with the blood solutions of a specific gravity higher or lower than that of the liquor sanguinis, in which the corpuscles floated in the natural state.† Now it has not only been proved that the red corpuscle possesses a membrane or envelope, but also that this envelope encloses a red fluid, and this being the case, it follows that the specific gravity of the enclosed red fluid must be identical with that of the liquor sanguinis, in which the corpuscle floats, such being the inevitable result of stasis when a permeable membrane separates fluids. With this knowledge let us now reflect on the change which will take place when the blood coagulates. The liquor sanguinis, in which the red corpuscles float, deposits its fibrin, and becomes thus converted into serum. Having

\* Med. Chirurg. Trans.

† Vide Guy's Hospital Reports, No. xiii. Rees and Lane on Anatomy, &c.

lost part of its solid contents, it now possesses a less specific gravity, and the fluid within the corpuscles, since it retains its normal specific gravity, is heavier than the serum in which the corpuscle floats, and consequently an interchange of fluid through the membrane will take place. In this way we find the corpuscle becomes filled by serum, to an extent which frequently renders its thickness half as great again as it is observed in blood before coagulation, for the reason that in accordance with the endosmotic laws, the lighter fluid without has entered the corpuscle in larger proportion than its heavier contained fluid could pass away. In this manner a portion of the serum, which in the natural state assisted in forming the liquid in which the corpuscles floated, has entered those bodies; and in our analysis of blood after coagulation, we possess no means of separating this serum from the corpuscle; it is, in fact, always retained permanently.

After the description I have now given of the physical structure and qualities of the red corpuscle, I trust the student will be prepared to consider the difficulties we have to encounter in accomplishing an analysis of coagulated blood, such as shall be perfect in all its parts.

I have stated that there are colourless bodies existing in the blood, which are to be seen under the microscope, and are known by the name of fibrinous corpuscles. It may be well to mention that these do not possess the vesicular character so strikingly shown by the red corpuscles, but that they are soft solids, the physical structure of which in no way interferes with the perfection of analysis, whereas we have seen that the endosmotic action set up during coagulation by the red corpuscles becomes a serious obstacle to our obtaining an absolutely correct analysis of the entire blood. I shall now proceed to describe the method employed for ascertaining the proportion of fibrin, red corpuscles, and serum contained in the blood.

My reason for commencing thus is, that I may gradually introduce the student from the simpler into the more intricate processes. I have, therefore, preferred to introduce this simple quantitative examination as a commencement to the more complicated qualitative analysis which follows, and which, in strict propriety, should have preceded. It

will be found, however, that this slight sacrifice of order is of the greatest utility to the student. Before noticing the qualitative examination of the various matters entering into the composition of blood, our object will be to describe, in as concise a manner as possible, the most approved processes for making the quantitative analysis of the serum, both in health and disease.

#### ON THE ANALYSIS OF THE BLOOD IN HEALTH.

##### *Determination of the Proportion of Water, solid Matters of Serum, Fibrin, and Red Corpuscles.\**

The blood intended for analysis is to be collected in three vessels, one of these being a platinum capsule, capable of

\* Several methods of effecting the separation of these three constituents of the blood have been proposed by chemists, and there are objections to all, in so far as absolute correctness is concerned. The process I have adopted I believe to be the best in medical inquiries, as it allows of the estimation of the corpuscles with greater precision than most others. The method recently proposed by Simon for the analysis of the entire blood possesses one great disadvantage: for the nuclei and capsules of the corpuscles are by him estimated as albumen, a defect which must render his results unsatisfactory to the pathologist, since a correct appreciation of the proportion of the corpuscles in their integral state is absolutely necessary to a clear understanding of many of the changes occurring in blood during the progress of disease. Simon has shown, however, that no very great discrepancies are to be observed between his results and those of other chemists. The method I now describe, which nearly approaches to that lately employed by Andral and Gavarret in their researches, is by far the most perfect with which I am acquainted. Many objections have been raised against it, of which the following only is deserving of notice. In the estimation of the proportion of serum and corpuscles, all the water of the blood is presumed to exist as a constituent of serum, and the corpuscles are assumed to be solids, whose moisture is entirely owing to the fluid in which they float, whereas in reality they are organised bodies containing, as a constituent, a fluid of a red colour, which is quite distinct from serum in its chemical relations. If we more minutely consider this plan of analysis in relation to the structure of the corpuscles, we shall observe, however, that it is capable of giving results far nearer to the truth than might at first be imagined. It must be remembered that

containing half a fluid ounce; the other two must be glass vessels, each of the capacity of six fluid ounces, and one of which should be a bottle or flask fitted with a glass stopper. The weights of the capsule and glasses in a perfectly dry state must be correctly ascertained, and, if possible, engraved upon them.

From two to three fluid drams of blood are to be received into the platinum capsule, and from four to six into each of the glass vessels. Ten or twelve pieces of lead, each about a quarter the size of a sixpenny piece, and the weight of which has been previously ascertained, are to be *immediately* put into the glass vessel provided with a stopper, and then shaken up with the blood, agitation being continued for ten or twelve minutes. By this action, the fibrin is made to coagulate around the lead. The bottle, with its contents, is now weighed, in order to ascertain the weight of blood operated on, which is at once done by subtracting the weight of the lead and bottle from the whole weight shown by the balance. The bottle is now to be emptied into a saucer, and the fibrin collected, washed with distilled water, dried, and weighed. This gives the weight of fibrin contained in the portion of blood operated on.

The blood received in the other glass vessel is to be set aside to coagulate, in order to afford a clear serum for analysis. The blood received into the platinum capsule is now to be weighed in that vessel, the weight of the capsule being subtracted from the whole weight shown by the balance, giving the true weight of blood. The capsule is next to be removed to a water bath, and the blood dried until it ceases to lose weight by further application of heat.

The capsule containing the dry matter is now to be wiped dry and weighed, and the weight obtained subtracted from that of the capsule and blood taken at the commencement

there is a constant endosmotic interchange of position taking place between the contents of the corpuscle and the liquor sanguinis, in which it floats, varying with the entrance and exit of water from the circulation; and that consequently the contents of the corpuscle will always be in part composed of those constituents of the blood which form the liquor sanguinis, and of which serum constitutes the greater part.



of the analysis. This gives us the weight of water contained in the portion of blood operated on.\* By subtracting the weight of the capsule from the weight shown by the balance, we also obtain the proportion of dry matter in the blood.

We have now ascertained the proportion of the following ingredients of the blood; viz.

Water,  
Solid matters, and  
Fibrin.

Now these results having been obtained on portions of blood differing in weight, our next step consists in reducing them, in order to ascertain the relative proportions of the ingredients contained in 1000 parts of blood. Having done this by the rule of proportion, we next subtract the weight of the fibrin (as adjusted to 1000 parts) from that of the solid matters of blood, of which of course it formed a part. We thus ascertain the weights of

Water,  
Fibrin, and  
Blood corpuscles and solid matter of serum mixed;

the two latter ingredients making up the remaining solid matters of blood.

The weight of the blood corpuscles and serum mixed together being known, it is obvious that if we ascertain the weight of either one of them, we shall be able to determine the weight of the other, by subtraction from the mixed weights. It is thus that we obtain the weight of the corpuscles by determining that of the solids of serum, which is done as follows. One hundred grains of serum, taken from the glass vessel which was set aside for coagulation of the contained blood are to be evaporated in a dish over a water bath until weight is no longer lost by further application of heat. The proportion of solid matter and water in

\* In thus using a small quantity of blood expressly to ascertain the proportion of water, we ensure exactness; for though we operate on a small weight, we do not move it from the capsule, or subject it to loss before weighing, and its small bulk ensures perfect drying over the water bath.



the serum is thus ascertained.\* Now we have already noted a weight of water in our analysis, as contained in 1000 parts of blood, and the solid matters of serum contained in the dry matters of blood will bear a proportion to that water. This proportion we have now determined by our experiment on 100 parts of serum. We now, therefore, merely have to make the calculation for the proportion of solid matters of serum indicated by the water in our analysis for 1000 parts of blood; and thus having ascertained the weight, we can also obtain that of the corpuscles by subtracting it from the known weight of the two together.†

\* The process in detail is the same as that for determining the proportion of water and solid matter in the blood, and may be performed in the balanced platinum capsule.

† The method of ascertaining the proportions of red particles, fibrin, and solids of serum here detailed, is only applicable when we can obtain blood before coagulation. When this cannot be managed it is best to use the method of Berzelius, which, though generally found to produce an over estimate of fibrin, still does not do so to any very material extent. The steps of the process are as follows:—

The weight of the whole quantity of blood operated on being noted, the proportion of water and solid matter in the serum is first ascertained by evaporating a known weight of that fluid to dryness in a salt-water bath; the loss of weight indicating the proportion of water, and the residuum the proportion of solid matter existing in the serum. These proportions being observed, the next step consists in dividing the crassamentum into two portions of equal weight; one of which is used to ascertain the proportion of fibrin, and the other the proportion of red particles, as follows:—

*Treatment of first Portion.*—The mass is to be cut into pieces as minutely as is possible, without losing any appreciable quantity of matter, care being taken that its precise weight be ascertained before comminution. The mass is now to be placed on a filter, with a stream of distilled or rain water so adapted that a constant supply be afforded to wash away the red particles and serum contained in the interstices of the clots. This process occupies some time, and may occasionally be assisted by careful pressure, exercised by the thumb and finger. In this manner the fibrin becomes freed from its admixture, and its weight is to be taken, after careful desiccation over a water bath.

*Second Portion of Crassamentum.*—The second portion is to be weighed, and then thoroughly dried over a salt-water bath. It is now again to be carefully weighed, the loss of weight indicating the proportion of water combined with the coagulum; but since all the water of the crassamentum may be considered to exist in combination as serum, we have to subtract from the weight of this solid residuum,

I shall next proceed to describe the manner of analysing the serum, by separating its various constituents, which is all that is now necessary to a perfect examination of the blood.

*On the Analysis of healthy Serum.*—Serum, the fluid part of the blood, which separates from the fibrin and red corpuscles on coagulation, contains the following constituents; viz.

Water.

Albumen.

Extractive matter, soluble in water and alcohol.

Albumen, combined with soda.

Crystalline fatty matter.

Animal oily matter.

Chlorides of potassium and sodium.

Alkaline, carbonate, phosphate, and sulphate.

Earthy phosphate and carbonate.

Subphosphate of iron.

Oxide of iron.

The process for making the quantitative analysis of the serum is as follows:—

The portion destined for analysis is first to be carefully weighed in a balanced china-ware capsule: 200 grains is frequently used by chemists; but if the operator can afford to wait the requisite time for the evaporations, I should recommend that he use 1000 grains in his experiments.

The weight of the serum being noted, it is now necessary to evaporate it to dryness over a water bath, and then, on

a quantity of solid matter proportional to the quantity of water, and which belongs to the serum, and not to the crassamentum. This is at once done; since the proportions of solid matter and water which compose the serum are ascertained at the commencement of the process. After this subtraction, it is obvious we have remaining the proportion of fibrin and red particles in admixture; but as the weight of the fibrin was obtained singly from the first portion of crassamentum operated on, we have only to subtract its weight, to ascertain the proportion of red particles. In this way we obtain the proportion of the fibrin and red particles: the deficit, of course, consists of serum; and the proportion of water and solid matter contained in this fluid being already ascertained, we can declare the weights of the water, solid matter of serum, fibrin, and red particles contained in any given specimen of blood.

ascertaining the weight of the dry extract, and subtracting it from that of the serum, we obtain the proportion of water contained in the specimen.

The dry extract is next to be carefully broken up in the evaporating dish,\* and then treated with boiling distilled water; care being taken that the heat be kept to 212 Fahrenheit at the moment of admixture, as otherwise the albumen is liable to assume a gelatinous form, which greatly interferes with the process. The quantity of water first added should be equal to about four times the bulk of the extract, and should serve to detach it from the sides of the evaporating dish: it then may be allowed to digest for a quarter of an hour, when it is to be thrown on a filter, which has previously been washed with hot distilled water, and allowed to drain. The contents of the filter are now again to be treated with boiling water, which is to be added by small quantities; a small portion of the liquor which passes through being occasionally tested with a solution of nitrate of silver, as it is necessary to continue the washings with boiling distilled water until the re-agent above mentioned ceases to be affected by the percolating fluid. We in this way procure a residue B, and a filtered solution A.

A, the solution, is now to be evaporated to dryness, the result weighed, and its weight noted. The next step consists in adding to the dry mass about four times its bulk of hot alcohol, which should be allowed to digest for ten or twelve minutes. This first portion serves to place the extract on a filter, and when the filtration is finished, two portions of hot alcohol, each equal in bulk to half the first, are successively to be allowed to wash the residue which will be observed on the filter; thus we have formed a clear solution C, and a second residue D.

C. This clear solution on evaporation yields the animal extractive or osmazome, soluble in water and alcohol; this is to be dried over a water bath, and its weight ascertained. From this datum we may likewise obtain the weight of the

\* This must be done by the aid of scissors, a spatula, a sharp knife; and the capsule should be placed on a dark-coloured sheet of glazed paper, in order that any portion of matter projected from it may be at once seen, and replaced.

albumen combined with soda ; which is done by subtracting the weight of the osmazome from the weight of the solid matter of the solution A.

D. This second residue is entirely soluble in distilled water, and consists of albumen combined with soda. Its weight may be ascertained directly, or inferred as above mentioned in process c.

B. This residue is to be dried and weighed ; successive portions of alcohol are now boiled on the mass until they no longer deposit stearine on cooling ; these alcoholic washings are to be added together, and evaporated over a steam bath. The residue B is to be again dried and weighed, which will afford the proportion of albumen. The dried fatty matters may now be washed with cold alcohol, which dissolves the oily and leaves the crystalline fat ; these may next be separately dried and weighed, to ascertain their proportion.

The following processes are now necessary, in order to render the analysis complete, by the determination of the proportion of alkaline and earthy salts. With this view, we must first incinerate the albumen, and keep the residue at a red heat in a platinum crucible over a circular-wicked lamp until all carbonaceous matter is dissipated ; the weight of the residuum indicates the proportion of earthy salts with an occasional trace of iron : this weight must be subtracted from the original weight of the albumen (obtained by process B,) in order to arrive at the exact proportion of that animal principle.

The proportion of alkaline salts may next be ascertained by incinerating the watery and alcoholic extracts obtained by processes c and d. The extracts must be separately incinerated, and the weight of salts in each be subtracted from the weight of the respective extracts, in order to ascertain the real weight of animal matter in each.

It will be observed, that the determination of the proportion of salts is a necessary step in order to ascertain the true amount of the animal matters.

The following results of two analyses, made by M. Lecanu, will serve to show the quantitative constitution of healthy serum :—

Water	-	-	-	-	906.00	901.00
Albumen	-	-	-	-	8.00	81.20
Organic matter, soluble in	}	water and alcohol			1.69	2.05
Albumen combined with soda					2.10	2.55
Crystalline fatty matter	-				1.20	2.10
Oily ditto	-	-	-	-	1.00	1.30
Chlorides of potassium and	}	sodium	-	-	8.10	7.32
Alkaline phosphate, sul-	}	phate, and carbonate			0.91	0.87
Earthy phosphate and car-	}	bonate, with phosphate	of iron	-	1.00	1.61
Loss	-	-	-	-		
					<hr/> 1000.00	<hr/> 1000.00

For those who cannot spare time to make an analysis as above, it may be well to mention the formula, as under, in accordance with which an analysis may be very easily effected :—

Water	-	-	-	-
Albumen, with earthy salts	}	and phosphate of iron*		
Animal extractives†	-	-	-	-
Fatty matters‡	-	-	-	-
Alkaline salts	-	-	-	-

I will now describe the method of proving the presence of the several salts above enumerated, as constituents of serum, beginning with the alkaline salts. These may be proved to be such by dissolving them, as obtained by incinerating the extractives, in a small quantity of distilled water, and then adding a few drops of a solution of carbonate of potassa to a portion of the saline fluid. The carbonate has the power of precipitating both metallic and earthy salts from their solutions, provided no excess of acid be

\* Avoiding the incineration of the albumen.

† Avoiding the separation by alcohol.

‡ Avoiding the separation of the crystalline fat from the oily matter.

present. It will be now observed, that the liquor remains unaltered by the addition of the re-agent; and we may therefore at once conclude that all the salts present are alkaline. To a second portion of the solution we may add an excess of tartaric acid, and set it aside for a few hours, when a crystalline precipitate will be procured, consisting of the bitartrate of potassa; thus indicating the presence of that base. A portion of the fused salts is now to be exposed to the inner flame of the blowpipe on a platinum wire, when the outer flame will become coloured yellow, in a very marked degree; proving that soda likewise exists in the salts.

Having now shown the nature of the bases, we will proceed to examine the acids with which they are combined:—1st. Let a portion of the dry salts be treated with a drop of moderately dilute acetic acid, when an effervescence ensues; proving the carbonic acid to be present.\* To a third portion of the solution of salts add a few drops of the solution of chloride of barium, which will occasion a dense precipitate, owing to the alkaline carbonate present. This precipitate must now be dissolved by a slight excess of pure hydrochloric acid, and the solution set aside, when a white precipitate of sulphate of baryta will appear, proving the presence of the sulphuric acid.†

A fourth portion of the solution is now to be rendered acid by a very slight excess of pure nitric acid, and then tested with a solution of nitrate of silver, which will occasion immediately a white precipitate, consisting of the chlo-

\* Enderlin denies the existence of a carbonate in the ashes of blood; and it is true, that if we incinerate the serum and crassamentum together, we obtain an ash which does not effervesce on the addition of acids. If we incinerate serum alone, however, we obtain an ash which effervesces strongly on the addition of acids. The explanation of the above apparent anomaly consists in the fact that the phosphorised fats contained in the clot produce during combustion a sufficient quantity of phosphoric acid to decompose the carbonate formed from the decomposed lactates and albuminate of the serum.

† If the whole of the precipitate be not dissolved by the excess of hydrochloric acid, we may also conclude that the solution contains a sulphate.



ride of silver; proving the presence of the hydrochloric acid. This precipitate may now be allowed to subside in the acid liquor, which is to be poured off into another tube, and to be carefully neutralised with ammonia. A yellow precipitate will then appear, which before was dissolved by the excess of acid. This precipitate consists of phosphate of silver, and may be further identified by allowing it to remain in the tube exposed to light for a few hours, when it will be found perfectly blackened; thus the phosphoric acid is shown to be present.

We will now proceed to the examination of the earthy and metallic salts: these will be found insoluble in water; an acid must therefore be used to dissolve them, which easily effects the purpose. The dilute nitric acid, perfectly pure, is to be preferred; care being taken to use little more than is absolutely necessary to effect the solution. It will be observed, that when the acid is added, effervescence occurs, occasioned by the escape of carbonic acid. The phosphoric acid may now be shown to be present, by the addition of a few drops of the solution of nitrate of silver to a portion of the acid fluid, and then neutralising the excess of nitric acid with pure ammonia;\* when the yellow phosphate of silver will be precipitated. The existence of this acid may also be demonstrated before the blowpipe, by subjecting a portion of the dry salts to the action of the inner flame, having previously moistened them with strong sulphuric acid, when the outer flame will assume a fine green colour.

Having now experimented upon the acids, we will proceed to the examination of the bases. To a portion of the acid solution add a sufficiency of ammonia nearly to neutralise it, and then let it be tested with the ferro-prussiate of potassa, when a precipitate of prussian blue or ferro-ses-

\* Great care must be taken that too great a quantity of nitric acid be not added in performing the solution of the salts; for in that case, the great excess of nitrate of ammonia (which is formed on the addition of the ammonia) tends to hold the phosphate of silver in solution. This fact of the solubility of the phosphate in ammoniacal salt will probably account for the frequent disagreements of chemists as to the existence of phosphates in some animal matters.

quicyanuret of iron will collect in the solution.\* Many minutes are sometimes required, however, before this effect is produced. In order to demonstrate the presence of the earthy phosphates, the acid solution must be neutralised with ammonia, when the peculiar gelatinous appearance of the precipitate will sufficiently characterise its nature.

QUALITATIVE ACCOUNT OF THE CONSTITUENTS OF THE  
HEALTHY BLOOD.

*Fibrin—Albumen—Globulin.*

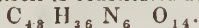
The blood is principally composed of proteine compounds, which are in combination with certain salts, fatty matters, and water, necessary either as solvents to the more important principles, or as assistants in the process of nutrition. The more important proteine compounds which we meet with in analysis are fibrin and albumen,† formed by the union of proteine with sulphur and phosphorus in varying proportion. To these most chemists add another, to which they give the name of globulin. This body is a constituent of the corpuscles—the white part of the corpuscles—and is made up of the nuclei and membranes which contained the red colouring fluid. It is estimated as a part of the corpuscles in the method of analysis I have detailed. The ashes of globulin have been erroneously stated to contain iron; this only happens when colouring matter has become mixed with it, for I have proved that the whole of iron contained in the blood exists in the red colouring

\* Iron exists as a mere trace in serum, and when found its presence is probably owing to accidental admixture with a small number of blood corpuscles.

† The ultimate constitution of these bodies has been stated as follows:—

	Fibrin.	Albumen.
Proteine. . . .	10 atoms	10 atoms.
Sulphur . . .	1	2
Phosphorus . .	1	1

The proportions of phosphorus and sulphur, however, cannot be relied upon. Proteine itself is constituted as follows:—



principle, and that the white matter of the corpuscles, when pure, yields a white ash.\*

The general chemical qualities of fibrin and albumen are almost identical, and the re-actions of the white matter of the corpuscles, so far as it has been examined, are of the same character. These principles are soluble in alkaline solutions, and precipitable when so dissolved on neutralisation with acids. They are rendered gelatinous, and dissolved by strong acetic acid.

Ferrocyanuret of potassium precipitates the acetic solution. Strong hydrochloric acid boiled on solid fibrin or albumen assumes a fine purple tinge. The ashes of fibrin, albumen, and globulin, when pure, are perfectly white, and composed principally of phosphate of lime. Albumen when in solution is precipitated on the application of a heat equal to about 160° Fahrenheit. It is coagulated also by the addition of—

Nitric acid,

Solution of bichloride of mercury, and  
ferrocyanuret of potassium,

provided a few drops of acetic acid be previously added.

Several metallic and earthy salts also precipitate albumen from some soluble forms of combination.

### *Hæmatosine.*

The red corpuscles of the blood, if collected in serum by washing the clot in that fluid, removing the coarser parts, and then allowing them to subside, may be made to yield hæmatosine free from globulin, by the following process:—The supernatant serum is to be poured off as nearly as possible without disturbing the corpuscles; a solution of common salt is next to be added, being of the same specific gravity as the decanted serum (about 1·029,) and the corpuscles having been agitated and washed in this fluid, are again to be allowed to subside, by which means they are freed from adhering albumen. Subsidence being complete, the next step consists in pouring away the saline solution, and throwing the subsided corpuscles into a vessel of dis-

\* *Vide* Guy's Hospital Reports, April, 1843, p. 323.

tilled water, which burst the corpuscles by rapid endosmosis, causing the burst vesicles to fall in the fluid together with the nuclei, while the red colouring matter dissolves in the water. The mixture is now to be placed on a filter, when the solution of hæmatosine will pass through, leaving behind the nuclei and membranes of the corpuscles. This solution, if evaporated, yields the red colouring matter in a state nearly approaching to purity. In this condition it will be found greatly to resemble albumen and fibrin in its re-actions with acids and alkalies. It yields, however, an ash rich in iron.\*

If we digest ether on dried blood, we obtain not only the fatty matters that we extract from serum, but in addition a fatty principle or principles containing phosphorus. The ethereal solution is clear, transparent, and of a yellowish colour. By spontaneous evaporation it leaves a reddish-brown residue, of the consistence of turpentine, which is formed of two very distinct substances; one being oily, and the other of a crystalline, fatty texture. These may be separated by cold alcohol, which dissolves the oily matter, leaving the crystalline matter unchanged.†

This crystalline, fatty matter is now to be dissolved in boiling alcohol, which deposits it on cooling in scales resembling mother of pearl; it is without odour or taste, soluble in cold ether and boiling alcohol, and insoluble in a solution of caustic potassa; when decomposed by heat, it leaves a residue, containing phosphoric acid; it has a great similarity to cholesterine in appearance.

The oily matter is now to be procured by the evaporation of the cold alcoholic solution. It is insoluble in cold and hot water; alcohol and ether dissolve it readily, assuming, at the same time, a yellow colour. It dissolves when gently heated in a solution of potassa; and if it be decomposed from its alkaline solution by hydrochloric acid, the fatty acids are formed.

\* Two colouring matters, called hæmaphæin and hæmacyanin, have been described by Simon and Sanson as constituents of healthy blood. The former is evidently altered, hæmatosine existing in minute quantity in serum. Of the latter I know nothing.

† Berzelius seems to consider a part of the fatty matters as peculiar to the fibrin.

Besides these fatty matters, we occasionally find cholesterine (a fatty matter supposed to be peculiar to the bile) mentioned as a constituent of blood ; and I have reason to believe it occasionally is present. Boudet mentions a fatty matter, to which he gives the name of serolin. His definition of this substance indicates properties nearly identical with those of the crystalline fat of the blood ; it is, however, less soluble in hot alcohol of  $\cdot 833$ , and fuses at a lower temperature than cholesterine, with which it also shows some characters in common.

### *Animal Extractives.*

In the analysis of serum two extractive matters have been noticed, one soluble in alcohol and water, the other soluble in water only. The former of these is called the alcoholic, the latter the aqueous extractive.

The alcoholic extractive is of a yellow colour, and deliquescent. Its properties are as follows:—It is soluble in water and alcohol ; precipitable of a brown colour by infusion of galls ; precipitable by the di-acetate of lead, the precipitate being soluble in an excess of that re-agent. This substance is what Berzelius once considered as lactate of soda, mixed with peculiar organic matter. It is the osmazome of some chemists. Lecanu says that it does not give out the odour of meat when boiled, which is the case with osmazome, and therefore thinks that the latter, as obtained by former chemists, consisted of this extractive matter, mixed with a portion of the fats, which would produce the odour in question. This is, indeed, more than probable ; since in most of the processes for obtaining osmazome no mention is made of any previous ethereal digestion, which would be necessary for the extraction of the fatty matters.

The aqueous extractive, when dry, forms a mass which Berzelius has considered as a result of the action of hot water on albumen. Lecanu, however, considers it to be a combination of albumen and soda, which is more than probable, as its solution in water gives a precipitate with acetic acid, resembling albumen in its gelatinous state ; and

as the same body may be procured without the use of hot water, it is plain that the action of that fluid is not necessary to its existence.

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## OF THE BLOOD IN DISEASE.

THE analysis of the blood has been so little studied by the medical profession until of late years, that we have but few observations to direct us regarding its diseased condition. The advance of animal chemistry has but just begun to produce those improvements in our pathological knowledge which have been long anticipated, and is gradually silencing those who argue against the utility of chemical investigations as applied to medicine.

The blood may be called diseased, either when any of its constituents become unusually abundant, or when a diminution of these proximate elements is observed. The more interesting deviation from health consists, however, in the existence of principles in the blood which are entirely foreign to its healthy constitution, and belong especially to the secretions or excretions of the body. A knowledge of the processes for the analysis of healthy blood will, of course, suffice to enable the experimenter very easily to analyse those specimens in which disease has either increased or lessened the proportion of any of the constituents. The substances foreign to healthy blood, and which chemistry has served to demonstrate as existing in the diseased condition of that fluid, are few in number, but yet the presence of each will require either a modification of the method of analysis or increased care and attention as to the degree of heat to be employed during the operations. Many observations have now been made in reference to the effects of disease in destroying the normal proportions of the principles of the blood: the most prominent among these changes are those in which the proportions of fatty matter and water become disturbed. The principles introduced into the blood by disease, and which will be espe-



cially noticed, are urea, colouring matter of bile, cholesterine, and sugar.

*Examination of Blood supposed to contain Urea.*

1. Let a portion of serum be accurately weighed, and then evaporated to dryness over an open steam-bath.\*

2. A quantity of distilled water (amounting to about one ounce for each 200 grains of serum used for experiment) is to be heated to 200° Fahrenheit, and then poured on the dry extract, which must be previously broken up with a sharp spatula.

A digestion over the steam-bath for about half an hour is now to be performed; the loss of water by evaporation being supplied occasionally by the experimenter.

3. The digested fluid is to be filtered, and the residue on the filter washed with distilled water (the washings being added to the original liquor.) The whole of the filtered liquor is now to be evaporated to dryness over an open steam-bath, and the residue of the evaporation digested, with absolute alcohol,† at a gentle heat, for half an hour; care being taken that the loss by evaporation do not materially diminish the bulk of the fluid.

4. A second filtration is now to be performed, and the filtered fluid must again be evaporated to dryness, and then dissolved in a small portion of lukewarm distilled water. We thus procure an aqueous solution of urea, combined with animal extractive; to this solution (previously evaporated to the consistence of a thin syrup) we now add a few drops of nitric acid, which causes an effervescence. This mixture must be set aside to crystallize.

5. Should crystals appear, of the peculiarly characteristic appearance of nitrate of urea, we may conclude that urea is present: indeed, if crystals exist at all after the foregoing

\* By using an *open* steam-bath, we are always certain of keeping the matter of experiment at a heat considerably below 212° Fahrenheit, which is absolutely necessary in these experiments, since urea in dilute solution becomes gradually destroyed if kept at the temperature of boiling water.

† About eight times the bulk of the solid extract for digestion.

process, they must be nitrate of urea ; since no principle of the blood that can possibly exist in the last-tested fluid possesses the property of becoming less soluble by the addition of nitric acid.

6. Crystals being formed in the liquor\*, we may now proceed to ascertain the proportion of urea. For this purpose we must first allow some time to elapse, in order that the deposition of crystals may be perfectly accomplished.† When such is the case, the supernatant liquor must be poured off; which, with the assistance of a small glass rod (to retain any very minute crystals) may be perfectly effected. The acid crystals remaining are now to be carefully dried over the open steam-bath and then weighed; from their weight we may infer the proportion of urea present, since we know the composition of nitrate of urea to be—

Urea	-	-	52·63
Nitric acid	-	-	47·37
			<hr/>
			100·00

If it be required to ascertain the relative proportion of the other ingredients of the blood containing urea, it will be right to make a separate analysis for that purpose; since the use of the open steam-bath and distilled water at 200° Fahrenheit will materially interfere with the determination of the quantity of albumen. I feel convinced that the wish to ascertain all by a single analysis has frequently been the cause of failure in the detection of urea when it existed in blood.

\* It will always be observed in specimens where urea exists, that, long before any material diminution occurs in the bulk of the fluid (which has been mixed with nitric acid,) a crop of crystals appears.

† This must be determined by the discretion of the operator, as it is impossible to lay down rules on such a subject; when any difficulty occurs, it is well to have recourse to the use of a freezing mixture, as recommended in the process for separating urea from the urine.

*Examination of Blood containing colouring Matter of Bile.\**

The best account which has yet been given of this diseased condition of the serum is by Lecanu, who satisfactorily proves that in jaundice the vital current is strongly impregnated with those matters, which in the healthy state are peculiar to the secretion of the liver. This able chemist has established, that in cases of jaundice the blood contains the following principles foreign to its healthy constitution :—

1. A combination of albumen and soda, scarcely at all soluble in water.

2. An orange-yellow colouring principle.

3. A blue colouring principle.

These colouring principles have been demonstrated to exist in the bile by M. Chevreul.

The examination of the serum of icteric blood is performed as follows :—

The serum is diluted with a considerable excess of alcohol, which renders it turbid, and precipitates a quantity of flocculi. These are collected on a filter, and washed repeatedly with cold alcohol. This filtered alcoholic solution is of a yellow colour, and possesses an alkaline reaction ; it yields a dark yellow coloured residue on evaporation, which has a saltish disagreeable taste. It is deliquescent, and almost entirely soluble in ether. The portion insoluble in the last-named menstruum is granular, and of a salt taste, without bitterness. It contains, besides salts, an extractive matter, soluble in alcohol, and another organic matter, such as is met with in healthy blood.

The ethereal solution is now left to spontaneous evaporation, when a considerable orange-yellow residue is obtained, which contains crystals of the crystalline fatty matter of the blood. These crystals may be separated by warm

\* It is probable that bile exists in serum in its perfect state ; but the colouring matter is that part which gives evidence of its presence, and therefore it is to the determination of this substance (to which the name of biliphæin has been given) that the attention of chemists has been principally directed.

alcohol, which also extracts an oily matter, of a beautiful deep yellow colour.\*

The albumen which has been precipitated is now to be treated with boiling alcohol, which assumes a dark green tint, and by cooling deposits crystals of fatty matter. The liquor, when cold, is to be filtered, and then evaporated over a water-bath. During the evaporation, it retains its original tint for some time; but when the alcohol is nearly dissipated, the green colour disappears, and a yellow tint is observable, while at the same time a portion of brownish matter deposits on the sides of the vessel. This brown deposit may be washed with cold alcohol, to free it from the other matters; when it will be found very soluble in boiling alcohol, and capable of producing a fine blue colour when dissolved in that liquid. It is remarkable that exposure to the rays of the sun destroys this colour.

The yellow serum of jaundice may be very easily tested for bile by the addition of nitric acid, which changes the colour to a delicate green after the lapse of a few minutes. This is a very simple method, and no less easy than it is satisfactory, and void of fallacy.

The jaundiced serum is thus described by Lecanu:—It possesses a sickly taste; it is of a saffron colour, which passes to a canary yellow on being diluted with water; it froths by agitation, and turns syrup of violets to a fine green colour.† No method is at present known of separating the biliary matters quantitatively from serum.

### *Examination of Blood containing Cholesterine.*

This principle is very easily discovered when it exists in blood; and many instances are on record, in which it has

\* This has been lately shown by Braconnot to consist of the yellow matter of bile in combination with an oily matter.

† See, in reference to this subject, Chevreul, Diction. des Sciences Naturelles, vol. xlvii. p. 198. Lassaigne, Journal de Chimie Médicale, Juin, 1826, pp. 264. 267. Examen Chimique du Sang dans l'Ictère, et Considérations sur cette Liqueur. Deyeux, Considérations Chimiques et Médicales sur le Sang des Ictériques. Collard et Martigny, Analyse Chimique du Sang d'une Femme morte ictérique, &c. &c.

been detected in icteric serum. The late researches of P. S. Denis have convinced him that cholesterine is not a constituent of healthy blood ;\* others believe it to exist in the healthy blood, Boudet among the number. However this may be, it is pretty certain that an increased proportion is occasionally present in disease. When serum is suspected to contain cholesterine, it should first be evaporated to dryness over a water-bath, and the dry residue digested with ether for several hours. The ethereal solution may now be decanted, and allowed to evaporate spontaneously. The residue consists of the fatty matters of blood combined with cholesterine.

These are to be well washed with cold alcohol, which extracts the oily matter of the blood, leaving the crystalline fatty matter and cholesterine. This latter may now be removed with the point of a penknife, or any fine instrument, as its crystals are very obvious and easily distinguishable.†

#### *Examination of Blood containing Sugar.*

Sugar has been detected in the serum of diabetic blood. The best method of determining its presence is that which has been lately proposed by Dr. Bence Jones, who recommends that the serum be first dried, and then that hot water be thrown on the powdered extract, by which means the albumen is separated, while the sugar and other constituents of the serum become dissolved. The filtered liquor may now be tested by Trommer's test as follows :—A few drops of a solution of sulphate of copper are to be added to the suspected fluid, so as to give it a pale blue tint. A solution of caustic potassa is next used to precipitate the copper salt; this being done, an excess of the potassa is to be added, in order that the hydrated oxyde of copper precipitated

\* Recherches Expérimentales sur le Sang Humain considéré à l'Etat sain. Par P. S. Denis.

† There is some difficulty in otherwise separating these two substances; for the crystalline fatty matter, like cholesterine, is insoluble in alkaline lixivia, and is very similar to that principle in all its reactions. Cholesterine, however, yields an ash having a strong alkaline re-action, which is not the case with that derived from the crystalline fatty matter of the blood.

may be redissolved in the alkaline menstruum. The solution will now assume a fine blue colour. Heat to a boiling temperature is next applied, when, if sugar be present, the oxyde of copper is thrown down as a precipitate of a reddish-brown colour, owing to the deoxydising action of the diabetic sugar on the oxyde of copper, which, were that principle not present, would assume a dark-brown tint on precipitation.

We know of no method at present of accurately ascertaining the proportion of sugar in diabetic blood.

The following process will yield sugar tolerably pure ; but does not enable us to determine its weight with precision.

The blood is to be evaporated to dryness over a water-bath, the dried mass comminuted and digested several hours in boiling water. The aqueous solution is to be filtered off, evaporated to dryness, and the dried residuum digested in alcohol of sp. 0·825. The alcoholic solution is to be filtered, evaporated to dryness, and treated with rectified ether, which dissolves out fatty matter, and some urea, leaving behind sugar, osmazome, and chloride of sodium. This mass on being dissolved in alcohol, and the solution allowed to evaporate spontaneously, affords a crop of mixed crystals, principally composed of alkaline, chloride, and diabetic sugar. These may be separated by careful manipulation. I have succeeded by the mechanical use of alcohol of low specific gravity, in effecting this by agitation, with a near approach to accuracy ; for the chloride sinks before the crystals of sugar, and thus allows of the latter being poured off partly dissolved in the fluid.

The following is an analysis I made of diabetic serum obtained from a patient, the specific gravity of whose urine was 1048 :—



Water	-	-	-	-	908.50
Albumen (yielding traces of phosphate of lime and oxyde of iron, on incine- ration)	-	-	-	-	80.35
Fatty matters	-	-	-	-	
Diabetic sugar	-	-	-	-	1.80
Animal extractive, soluble in alcohol, urea					2.20
Albuminate of soda	-	-	-	-	0.80
Alkaline chloride, with traces of phosphate					4.40
Alkaline carbonate, and trace of sulphate, the results of incineration	-	-	-	-	
Loss	-	-	-	-	1.00
					<hr/> 1000.00 <hr/>

I should wish the proportion of diabetic sugar given here to be considered merely in the light of an approximation, as it is impossible to separate it completely from impurity; and the loss sustained during manipulation must be considerable.

## ON THE URINE.

I SHALL commence this subject by describing each constituent of the urine, and shall then proceed to give an account of the method used for the performance of the quantitative analysis. In considering the urine in disease, I shall, first, treat of the urinary deposits; and, secondly, of those diseased conditions of the fluid which do not necessarily cause any sediment or turbidity. The examination by reagents will be noticed; and then a particular account given of the method for the quantitative analysis of certain forms of unhealthy urine.

## OF THE URINE IN HEALTH.

The urine in health has been stated by Berzelius to contain, besides water, the following substances as ingredients; each of which will be separately noticed:—

Urea.

Free lactic acid.\*

Lactate of ammonia.

Osmazome.

Animal extractive (soluble in water only.)

Lithic acid.

Vesical mucus.

Sulphate of potash.

Sulphate of soda.

Phosphate of soda.

Phosphate of ammonia.

Chloride of sodium.

Hydrochlorate of ammonia.

Phosphates of lime and magnesia.

Silica.

\* Liebig denies the existence of lactic acid as a constituent of urine, and adds hippuric acid as present in healthy urine. He seems to think that the substance mistaken by Berzelius for lactic acid was a nitrogenous resinoid body produced during evaporation together with acetic acid.

*Urea.\**

The following process is, perhaps, the best for procuring this principle in a separate form:—

Evaporate urine to the consistence of a strong syrup, and then add pure concentrated nitric acid, until the whole mass becomes more or less solid. The crystalline matter which is now produced consists of nitrate of urea. This must be washed from adherent impurities by ice-cold water, and then pressed between folds of bibulous paper to dry. These crystals are now to be dissolved in lukewarm distilled water, and neutralised with carbonate of barytes. This mixture is to be evaporated to dryness, and alcohol boiled on the dried mass. In this way the urea may be extracted from the barytic salt. It may be obtained in colourless crystals, by digesting the alcoholic solution with animal charcoal, then filtering, and allowing the urea to crystallise by spontaneous evaporation. The chemical properties of urea are as follows:—

When heated on platinum foil it fuses; and if the heat be urged is decomposed, yielding fumes of carbonate of ammonia.

It is very soluble in cold water, but more so in warm. It gives out a great degree of cold when dissolved in any considerable quantity.

The concentrated solution in water will bear a heat of  $212^{\circ}$ , without decomposition; but in dilute solution it quickly decomposes at that temperature.

Alcohol of specific gravity 0.816 dissolves a fifth of its weight of urea at  $60^{\circ}$  Fahrenheit; when boiling it dissolves nearly its own weight.

It is slightly soluble in ether. The caustic alkalies decompose urea into carbonate of ammonia.

The nitric oxalic acids combine with urea, forming salts,

\* This important constituent of the urine has been supposed by some to form during evaporation. Mons. Cap and Henry believe it to exist in the form of lactate. It is neither formed by evaporation, nor present as lactate, however, for I have succeeded in separating it without evaporation, and that too in a pure state, by agitating urine with the common rectified ether of the shops, and evaporating the ethereal solution which separates above.

more or less insoluble. The crystallization with nitric acid forms one of its best distinctive characters.

Urea possesses neither an acid nor alkaline reaction: its crystalline form is that of a four-sided prism, exceedingly delicate, and silky in texture.

### *Lactic Acid.*

The lactic acid was first stated to exist in the urine by Berzelius, who extracted it by the following process:—

A portion of urine was evaporated to dryness, and alcohol of specific gravity 0·833 boiled on the solid residuum.

The alcoholic solution was now evaporated, and the mass dissolved in water.

The watery solution was then boiled with a considerable quantity of hydrate of lime, till all ammoniacal fumes (from decomposing urea) were dissipated; the hydrate of lime now became coloured yellow, owing to the decomposition of animal matter.

The colourless solution was filtered, dried, and then treated with alcohol of specific gravity ·845. Equal parts of strong sulphuric acid and water were now added, guttatim, to the alcoholic solution, until sulphate of lime no longer precipitated; the clear liquor being decanted was next treated with carbonate of lead, recently precipitated,) and was then filtered and evaporated to dryness.

The residue was treated with oxide of lead and a little water, by which means the lactic acid was converted into a sub-salt of considerable insolubility. This was collected, washed with water, and then decomposed by sulphuretted hydrogen.\* Thus, sulphuret of lead subsided, leaving the lactic acid free in the supernatant liquor, which, by evaporation, yielded it in the form of an acid yellow syrup, exceedingly deliquescent, and incapable of being thoroughly dried by heat.

Its chemical properties are the following:—

\* This is done by suspending the precipitate in distilled water, and allowing a jet of sulphuretted hydrogen to pass through the liquid to saturation.

It gives out an acrid odour\* when heated, and leaves a porous charcoal if the heat be continued. Alcohol dissolves it in all proportions. It is nearly insoluble in ether.

Its salts are all of a gummy and uncrystallizable nature, excepting the lactates of zinc and magnesia, which have been obtained in a crystalline form.

When lactic acid is added to a strong solution of the acetates of magnesia or oxide of zinc, the lactates of those bases are precipitated.

### *Osmazome.*

This is a term used to signify an animal extract, soluble both in water and alcohol. Such exists in the urine, and may be procured by digesting alcohol of specific gravity  $\cdot 833$  on an extract of urine; and after crystallizing the urea from the alcoholic solution (by means of nitric acid,) separating the uncrystallizable matter, and neutralising it with carbonate of baryta: the mass must then be dried, and alcohol will now extract the osmazome from the barytic salts.†

Its chemical properties are as follows:—

When heated it swells much, and leaves a copious alkaline carbonaceous mass.‡ It reddens litmus paper.

Neither chloride of mercury, nor the acetate of lead, is capable of precipitating its watery solution.§

Both acid and alkaline solutions are incapable of effecting any precipitation of this extract from its solution in water.

Protochloride of tin, nitrate of silver, and di-acetate of lead, produce precipitates.

It may be well to mention, that if anhydrous alcohol be digested on this osmazome, it is capable of being divided into two portions; the one soluble and the other insoluble in that fluid.

The property of being precipitated by the diacetate of

\* Not unlike that of the tartrates.

† This will not be quite pure, but sufficiently so to exhibit its properties.

‡ It contains an alkaline lactate.

§ If these salts produce a precipitate, it is because alcohol has been used of higher specific gravity than  $0\cdot 833$ .

lead, nitrate of silver, and protochloride of tin belongs peculiarly to that part of the extractive matter which is soluble in anhydrous alcohol.

*Animal Extractive (soluble in Water only.)*

This matter may be procured by dissolving in water an extract of urine which has been digested with alcohol of specific gravity 0.833. By the resolution we separate any vesical mucus, lithic acid, earthy phosphate, or silica, which may be contained in the mass. The solution is now precipitated with acetate of baryta, in order to rid it of sulphuric acid. The sulphate of baryta is collected on a filter, and the filtered liquor neutralized with ammonia, and then again precipitated with the acetate, which now causes a precipitate of phosphate of baryta.\* This is to be collected, and the filtered liquor evaporated, in order to drive off the ammonia; or what is better, it may be neutralized by acetic acid. Neutral acetate of lead is now added to the solution, which causes a copious precipitate. This must be collected and washed, and then decomposed by sulphuretted hydrogen, which precipitates sulphuret of lead, and leaves the animal extractive in solution, which may be obtained by evaporation. This extractive is, however, but part of that meant to be understood as the "animal extractive soluble in water only," so often mentioned in analyses. The remainder of it may be procured by precipitating the liquor (in which the precipitate by neutral acetate of lead subsides,) by means of the di-acetate of lead†; then collecting the precipitate, decomposing it as before by sulphuretted hydrogen, and procuring the extractive from the clear liquor. It must be remembered that each of these extractives have peculiar properties; perhaps dependent on the processes used to obtain them. There is also a portion of animal extractive left unprecipitated by the di-acetate of lead. It is easily obtained from the liquor by ridding the solution of any lead

\* Both these precipitates produced by acetate of baryta contain animal matter, which in the latter case is in very considerable proportion.



which may exist in it by means of sulphuretted hydrogen, filtering, and then evaporating to dryness.

It is a mixture of these three peculiar extractives which constitutes the “animal extractive soluble in water only” of Berzelius.

The properties of the extractive matter precipitated by the neutral acetate of lead are the following:—

It is of a brownish colour, translucent, and does not deliquesce; has no taste, and scarcely affects litmus paper.

Its solution is rendered cloudy by bi-chloride of mercury, and more so by the proto-chloride of tin.

The extractive precipitable by the di-acetate of lead has the following properties:—

It is of a yellowish-brown colour, has a slightly bitter taste, and does not deliquesce.

The watery solution of this extract is of a deep yellow tint.

It is not precipitable by the solution of bi-chloride of mercury, but the proto-chloride of tin, the di-acetate of lead, and nitrate of silver, precipitate it of a dark-brown colour.

The third extractive which was precipitated neither by the acetate nor di-acetate of lead, possesses the following characters:—

It is of a yellow colour. Solutions of bi-chloride of mercury, proto-chloride of tin, and nitrate of silver precipitate its aqueous solution. The precipitate produced by the last of these reagents is of a dirty yellowish-red colour.\*

### *Lithic Acid.*

This acid may be procured from the urine by the addition of a few drops of strong hydro-chloric acid, which, after the lapse of some hours, produces a reddish crystalline precipitate of lithic acid. The red colour is caused by an admixture of colouring matter of urine; for pure lithic acid is perfectly white. It may be obtained in a pure state from the red crystals by dissolving them in caustic potash, and

\* For further examination of these extractive matters, see the article by Berzelius in his *Traité de Chimie*, vol. vii. p. 380. *Sur les Matières indéterminées dans l'Urine.*

then precipitating the solution by the addition of hydrochloric acid. The precipitate may now be collected, and washed on a filter.

For the chemical properties of lithic acid, see the article on the analysis of urinary calculi.

### *Vesical Mucus.*

This substance always exists in healthy urine, but is scarcely to be observed when in normal proportion. It may be procured from urine by throwing it on a filter immediately after evacuation, when we may collect it in transparent colourless flocculi, which, if allowed to dry on the filter, possesses a shining appearance. The addition of water, however, immediately restores the original form of the flocculi. It possesses the following chemical properties:—

The acetic and nitric acids dissolve it readily, and the solution is precipitated by the ferro-cyanuret of potassium.

Caustic potash dissolves it, and ammoniacal fumes are produced.

It does not dissolve in sulphuric acid.

When mucus exists in considerable quantity in urine, it may be easily recognised by its glairy tenacious appearance. It never, therefore, can be mistaken for pus; but when small quantities of both are present, we are occasionally at a loss to determine the truth by chemical means, and are obliged to have recourse to the microscope. When pus is present in urine with mucus, we sometimes find it lying on the latter, and possessing a yellower tint; it is also opaque, whereas mucus is more or less transparent.

### *Salts.*

These consist of alkaline sulphates, chlorides and phosphates, the earthy phosphates, and silica. They may all be procured for examination by incinerating the urine, if we except the hydro-chlorate of ammonia, which becomes dissipated by calcination, and must be procured by a separate process. I shall first notice the manner of extracting this

last-mentioned salt, and then proceed to a general description of the remainder.

To extract the hydro-chlorate of ammonia, a portion of urine must be exposed during several days, by which process we find a crystallization of various salts to occur at the bottom of the vessel. These consist principally of the chloride of sodium, hydro-chlorate of ammonia, and ammoniaco-phosphate of soda, mixed with earthy phosphates.

These crystals may now be collected on bibulous paper, the cubes extracted from the other crystals, and dissolved in distilled water; from which they may be re-crystallized, in order to rid them of adhering animal matter.\* These crystals may be recognised as hydro-chlorate of ammonia by the following characters:—

When heated with potash, vapours of ammonia are evolved, to be recognised as such by their odour, as well as by forming a milk-white vapour if mingled with those of hydro-chloric acid. The crystals are volatile, and easily sublimed. The solution is precipitated by the addition of nitrate of silver.

The other alkaline salts which may be obtained by incinerating dried urine are separated from the earthy phosphates and silica by being dissolved in water; the residuum can be left for after-examination. The solution may now be shown to contain chlorides, phosphates, and sulphates, by the addition of solutions of nitrate of silver and nitrate of baryta to separate portions of the liquor.

The nitrate of silver will throw down a copious white precipitate, which will be in part only soluble in pure nitric acid; thus showing the insoluble chloride of silver and more soluble phosphate. If the chloride be allowed to subside in the acid solution, and the clear supernatant liquid be then poured off, we shall find that on neutralizing the nitric acid present by the cautious addition of caustic ammonia, we can reproduce the precipitate of phosphate of silver, possessing its characteristic yellow colour.

It now remains to show the presence of sulphuric acid,

\* The chloride of sodium crystallizes from the urine in octohedrons, owing to the existence of urea in the solution. We avoid that chloride by selecting the cubes.

which is done by adding a solution of nitrate of baryta to a second portion of the liquid; when a copious white precipitate occurs, consisting of sulphate of baryta, which will be found insoluble in strong nitric acid.

Having thus proved the salts to contain the above acids, we must next show the nature of their bases. This may be done by adding a solution of carbonate of potash to a portion of their solution, when we shall find no precipitate to occur; a fact that shows we are operating on alkaline salts.

We may now direct our attention to the residuum, which was insoluble in water, consisting of earthy phosphates and silica.\*

The phosphates, consisting of phosphate of magnesia and lime, may be separated from the other insoluble ingredient by digestion with dilute nitric acid, which readily dissolves the phosphates. This solution may be tested for lime with oxalate of ammonia (the liquor having previously been nearly neutralised by caustic ammonia,) when a precipitate of oxalate of lime occurs: this takes some time collecting, and it is well to boil it briskly and leave it to cool gradually. When the precipitate has quite subsided, if the clear liquor be poured off, and then rendered alkaline with ammonia, we procure after some time a crystalline precipitate of the ammoniaco-magnesian phosphate: thus we ascertain that magnesia and lime are the earthy bases.

If a considerable quantity of urine has been subjected to experiment, we now have a residue which consists of silica.†

This is easily recognised by being insoluble in strong aqua regia, and forming a perfectly transparent and colourless glass with soda before the blowpipe.

Having now become acquainted with the reactions of the various constituents of the healthy urine, we are prepared to enter on the consideration of its quantitative analysis; a

\* It must be observed, that in order to procure any quantity of this residue, it is necessary to employ a large bulk of urine for evaporation.

† This has been said to contain traces of fluete of lime; but confirmation is necessary on this point; indeed, there must be great difficulty in proving the presence of a fluete when it exists as a trace, and that, too, in combination with silica.

subject which, carried to its fullest extent, may be regarded as one of the most difficult undertakings of the chemist.

#### ON THE QUANTITATIVE ANALYSIS OF HEALTHY URINE.

It is not my intention to enter deeply into the quantitative analysis of the urine, but rather to give the process to that extent which is requisite for medical inquiry. I do not scruple to assert, that up to the present time, our knowledge of animal chemistry is far from adequate to exhibit in a separate form all the various constituents of a fluid so complex and destructible as the urine. The laborious researches of the much respected Berzelius served but to convince him of the futility of an attempt of the kind, and he concludes the description of a tedious process with the following remark: “*Cette marche serait celle à suivre dans l’analyse de l’urine, telle qu’on peut l’exécuter actuellement. Un temps viendra, sans doute où elle paraîtra forte imparfaite.*”

The following is the quantitative analysis of the urine, as performed by Berzelius:—

Water	-	-	-	-	933·00
Urea	-	-	-	-	30·10
Free lactic acid	-	-	-	}	17·14
Lactate of ammonia	-	-	-		
Osmazome	-	-	-		
Extractive, soluble in water only	-	-	-		
Lithic acid	-	-	-	-	1·00
Vesical mucus	-	-	-	-	0·32
Sulphate of potash	-	-	-	-	3·71
Sulphate of soda	-	-	-	-	3·16
Phosphate of soda	-	-	-	-	2·94
Biphosphate of ammonia	-	-	-	-	1·65
Chloride of sodium	-	-	-	-	4·45
Hydrochlorate of ammonia	-	-	-	-	1·50
Phosphate of lime and magnesia	-	-	-	-	1·00
Silica	-	.	-	-	0·03

This form of analysis involves many troublesome processes for the separation of matters at present unimportant

to the consideration of medical inquirers. I shall therefore adopt a modification of the above which will be found both simple and satisfactory. The form is as follows:—

Water	-	-	-	-
Urea -	-	-	-	-
Free lactic acid	-	-	-	}
Lactate of ammonia	-	-	-	
Osmazome -	-	-	-	
Animal extractive, soluble in water only	-	-	-	
Ammoniacal salts	-	-	-	}
Alkaline sulphates	-	-	-	
Chloride of sodium	-	-	-	
Phosphate of soda	-	-	-	}
Earthy phosphates and silica	-	-	-	
Lithic acid -	-	-	-	}
Vesical mucus	-	-	-	

By this form of analysis we omit the determination of the proportions of lithic acid and ammoniacal salts: the former exists in the healthy urine in the proportion of 1-10th per cent., and the latter also in slight proportion. The proportion of lithic acid may be easily ascertained by using a portion of urine for the express purpose; as the addition of acid determines its precipitation after a few hours have elapsed, and it can then be collected on a filter, washed with distilled water, and weighed.\*

The process for fulfilling the formula is as follows, two portions of urine of 1000 grains each being requisite for that purpose.

*First Portion.*—This is evaporated over a steam-bath to dryness, and the weight of the residue noted; which being subtracted from the original weight (1000 grains) will give the proportion of water present. Alcohol, specific gravity .833, is now to be boiled on the dry extract in separate quantities, until no further action is exerted by it. By this

\* Hydrochloric acid should be used for precipitating the lithic acid, in the proportion of about 1 dram to 1 pint of urine, which must be evaporated to half its bulk before the addition of the acid.



means we obtain an impure solution of urea, which is to be purified as follows:—An extract is first made from the alcoholic solution, and then it is re-dissolved in lukewarm distilled water; to this solution oxalic acid is to be added, until no more becomes dissolved on heating the liquid to  $200^{\circ}$  Fahrenheit. When the liquor cools, a deposit of crystals of oxalate of urea occurs, which are impure and dark-coloured; these are collected on a filter, and washed with a very small quantity of distilled water. This water, together with the mother-liquor, is evaporated to procure any more crystals which may exist in the solution; care being taken, if the liquors be not acid, that more oxalic acid is added to them at a heat of  $200^{\circ}$  Fahrenheit, when we shall obtain a fresh quantity of crystals on cooling. These crystals, being collected together, are dried between folds of bibulous paper, then redissolved in water, and neutralised with carbonate of lime; the liquor is filtered, and the precipitate well washed. The filtered liquor and washings, being a solution of urea, are then evaporated to dryness over a steam-bath, and the extract weighed. Anhydrous alcohol should dissolve the whole of this; and if there be any portion insoluble in that menstruum, its weight must be deducted from that of the weighed extract, and thus we ascertain the exact weight of the urea.

The residue which resisted the action of alcohol .833 is now to be treated with water, which leaves an insoluble residue, consisting of vesical mucus, lithic acid, earthy phosphate, and silica; this residue is to be dried and weighed; the weight being noted, the mass is to be incinerated in a platinum capsule. The result of the incineration is silica and earthy phosphates, the weight of which may now be taken.

The loss of weight by incineration will indicate the proportion of lithic acid and vesical mucus.

We have now ascertained from the first portion of urine the proportion of the water, urea, lithic acid and vesical mucus, earthy phosphates, and silica.\* It remains for us

\* It may be remarked, that if any very notable proportion of these two latter is observed, their separate weights may be taken by extracting the phosphates with dilute muriatic acid, and weighing the remaining silica. This, with the previous knowledge of the mixed weights, enables us to determine the weight of each.

to determine the weight of the alkaline salts and various animal extractives ; this is done with the second portion of urine.

*Second Portion.*—These 1000 grains are to be evaporated to dryness over a steam-bath, and the weight of the dry extract again ascertained, in order to assure ourselves of the correctness of our former experiment. The extract is now carefully incinerated and decarbonised in a platinum crucible: the weight of the result being taken, and then subtracted from that of the dry extract, gives us the weight of the animal extractives, &c. &c., plus that of the urea, vesical mucus, and lithic acid ; but the proportion of these latter being already ascertained, we have but to deduct their weight to ascertain that of the extractives.

The weight of the result of incineration, minus that of the earthy phosphates and silica, is the weight of the alkaline salts. Thus we have fulfilled the formula, which may, if required, be further extended by ascertaining the proportion of each of the alkaline salts.\*

#### ON THE ANALYSIS OF URINE IN DISEASE.

The analysis of urine in disease has been practised with far more advantage and success than that of the blood in its unhealthy condition. This, doubtless, is owing to the more frequent opportunities offered to the physician for inspecting the urine, and also to the more obvious marks of disease presented by that fluid. The most frequently observed variation from health is that of the existence of a deposit, which is generally produced on the fluid becoming cool after evacuation, but is sometimes voided with the urine in a precipitated state. I shall first notice the chemical constitution of these deposits.

#### *Analysis of Urinary Deposits.*

Most of these deposits are precisely similar in constitution to urinary calculi, and therefore the same rules are applicable to their analysis.

Some of the urinary deposits have been arranged accord-

\* *Vide* Appendix.

ing to their colour by Dr. Prout ; who notices the following varieties :—

Yellowish or nut-brown sediment.    -    -    -	{ Lithate of ammonia. Colouring matter of urine. Earthy phosphates and lithate of soda.
Reddish-brown or lateritious sediments.    -	{ Alkaline lithate. Colouring matter of urine. Alkaline purpurate.* Occasionally, earthy phosphates.
Pink sediments    -    -	{ Lithate of ammonia. Purpurate of ammonia.

These consist, for the most part, of lithic acid, in combination with a base. There exists, however, the free lithic acid ; as,

Red crystalline sediment	{ Lithic acid. Colouring matter of urine.
--------------------------	--

We have next to notice the phosphatic sediments, which are mostly of a dead-white colour.†

Amorphous sediment -	{ Triple phosphate. Phosphate of lime, in variable proportion.
Crystallised sediment -	{ Triple, or ammoniaco-magnesian phosphate -

We must add to these the oxalate of lime deposit, the deposits of red corpuscles, of pus, mucus, bile, and cystine.

I shall proceed to notice the plan to be adopted in the analysis of these deposits, commencing with—

\* Dr. Prout still adheres to the old name for this colouring matter. It appears, however, from the researches of Liebig, that the purpurate of ammonia is not a salt. but a distinct principle, to which he gives the name of murexid. The purpuric acid of Prout is called murexan by Liebig.

† I have occasionally met with the lithates of as pure a white as the phosphates. This is by no means common, however.

*Yellowish or Nut-brown Sediment,\**

Consistidg of

Lithate of ammonia.

Lithate of soda.†

Earthy phosphates.‡

Colouring matter of urine.

The deposit is to be boiled in distilled water, which extracts the lithate of ammonia and lithate of soda, leaving the earthy phosphates§

For the examination of the earthy phosphates, see the article on the analysis of phosphates in healthy urine, page 52.

The aqueous solution is to be evaporated to dryness, and a portion of the mass treated with nitric acid; which, with the assistance of heat, yields on drying the purple tinge characteristic of lithic acid, which is increased on the addition of ammonia: thus we prove the presence of lithic acid.

A second portion of the dried mass is mixed with caustic lime on platinum foil; when vapours of ammonia will be observed, known by their odour, and by affording a white vapour when mingled with fumes of hydrochloric acid: thus ammonia is detected.

A third portion of the mass is heated to redness on platinum foil; when a residue is obtained, possessing an alkaline re-action, and dissolving in distilled water, thus showing the presence of fixed alkali. This is proved to be soda by directing the tip of the inner flame of the blowpipe upon it; when the outer flame becomes coloured yellow, which is not the case with either potash or lithia. Before finishing the notice of this deposit, I must state that I have occasionally detected lithate of lime in it. This was proved to be present by the solubility of the deposit in warm dilute nitric acid, and the detection of caustic and carbonated lime as a result of incineration.—N. B. No effervescence

\* Lithates of lime and magnesia often occur in the nut-brown deposit, in small proportion.

† This is almost always in small proportion.

‡ The phosphate of lime exists in this deposit.

§ This holds the colouring matter in combination.

was produced by the addition of hydrochloric acid to the deposit previous to incineration. No oxalate of lime was present, to whose decomposition the carbonate of lime (of incineration) might be attributed.

*Reddish-brown or Lateritious Sediment,*

Said to consist of

Alkaline lithate.

Colouring matter of urine.

Alkaline purpurate.

Earthy phosphate (occasional.)

The deposit is first to be boiled in a considerable quantity of distilled water, which leaves undissolved any earthy phosphate which may be present. The lithate and colouring matter are held in solution.

The presence of the lithate may be proved as in the first described deposit, the presence of soda being particularly sought for.

*Pink Sediment,*

Said to consist of

Lithate of ammonia, coloured by

Purpurate of ammonia.

The existence of lithate of ammonia in this deposit is to be proved in the way described above for the examination of the yellowish sediments. For an account of the colouring matter, see Appendix.

*Red Crystalline Sediment,*

Consisting of

Lithic acid,

Colouring matter of urine.

This deposit may be proved to consist of lithic acid, by yielding all the re-actions mentioned in the article on the examination of lithic acid calculi.

The colouring matter may be separated by boiling the sediment in distilled water.

*Amorphous Sediment,*

Consisting of

Ammoniaco-magnesian phosphate.

Phosphate of lime.

This sediment may be known by the following chemical characters :—

It is insoluble in water.

It readily dissolves in the dilute acids, from which it is precipitated on the addition of ammonia.

It yields ammoniacal fumes, when treated with caustic potash.

Its solution in acid, if it be first nearly neutralised with ammonia, yields a white precipitate of oxalate of lime when tested with a solution of oxalate of ammonia ; and if after the subsidence of this precipitate we pour off the clear liquor, and test it with ammonia, we shall perceive, after some time has elapsed, a crystalline precipitate of triple phosphate to occur in the liquor : thus we prove lime and magnesia to be present.

The phosphoric acid is shown to exist in the solution by the re-actions of nitrate of silver. See p. 50.\*

*Crystallised Sediment,*

Consisting of

Ammoniaco-magnesian phosphate.

This dissolves in acids, and is precipitated from its acid solution by the addition of ammonia, like the preceding deposit ; but does not yield a precipitate on the addition of oxalate of ammonia to the nearly neutralised solution in acid, in consequence of having no lime in its constitution. This is its best distinguishing characteristic.

As with the preceding sediment, ammonia is evolved when it is treated with caustic potash.

*Oxalate of Lime Sediment.*

This deposit may be known by the following characters : viz.

\* This amorphous sediment frequently simulates pus in appearance ; but may be easily distinguished, the latter being dissipated before the blowpipe.



It is insoluble in water and warm dilute nitric acid. When heated before the blowpipe on platinum foil, it leaves a residue of carbonate of lime, which may be known as such by its insolubility in water, solubility with effervescence in dilute acids, and precipitation from this solution by oxalate of ammonia.\*

### *Red Corpuscles.*

This sediment, when present in small proportion, requires the use of the microscope for detection ; when in large proportion, it can never be mistaken, on account of its peculiar colour. It may sometimes be identified by the property it possesses of becoming of a very bright red colour, when treated with a concentrated solution of chloride of sodium. The deep porter colour occasionally observed in urine may frequently be traced to the existence of red corpuscles in suspension.

The existence of pus and mucus as a deposit in urine is of very common occurrence. I have before stated, that when in small proportion it becomes a matter of difficulty to discriminate, and we are obliged to use the microscope in order satisfactorily to determine their presence.†

### *Biliary Sediment.*

This frequently remains on the filter through which jaundiced urine has passed. It consists of the yellow colouring matter of bile. Its properties are as follow :—

It is insoluble in water.

It dissolves readily in caustic potash.

When dilute muriatic acid is thrown on it, a fine green colour is produced.

The addition of strong nitric acid produces a red colour.

\* These three experiments can be made in a watch-glass or small test tube, without removing the result of the blowpipe experiment, which may be a very minute quantity. First, the water is added, which has no solvent action ; secondly, the addition of acid to this water causes effervescence and solution ; and thirdly, the addition of oxalate of ammonia throws down a precipitate.

† When pus is present in quantity, it frequently simulates the phosphates, but may be distinguished by the addition of caustic potassa in solution, when, if pus be present, the whole mass of deposit becomes mucoid and tenacious. This excellent test was proposed by Dr. Babington.

*Cystine.*

This deposit may be known by the following properties:—

It dissolves in caustic ammonia, and is precipitated from this solution by acetic acid.

It is insoluble in alcohol, water, and solution of carbonate of ammonia.

It is soluble in the nitric and hydrochloric acids.

It is soluble in the caustic fixed alkalies, and in their carbonates.

Braconnot gave the name of Cyanourine to a colouring matter he detected in the urine. It has not been observed in connection with any particular form of disease. It tinged the whole urine of a blue colour.

The following are its characters, according to Braconnot:—

It is tasteless, void of odour, darker than prussian blue, and in a very finely divided powder.

When heated, it yields carbonate of ammonia and empyreumatic oil.

It is slightly soluble in water and boiling alcohol. This alcoholic solution is green, and on cooling, it deposits a dark blue powder, having a crystalline appearance.

This powder is dissolved by the acids, and is thus turned to a red colour.

Its solution in dilute sulphuric acid yields a fine carmine colour on evaporation to dryness; and this residue is rendered brown by solution in water, but resumes its carmine tint on evaporation to dryness.

When the red acid solutions of this colouring matter are neutralised with alkali, the original blue colour is restored, and a precipitate produced.

Caustic potash acted but little on this blue colouring principle, and carbonate of potash had not the slightest effect upon it.\*

Other sediments have been described of a black colour by Drs. Marcet and Prout. These, however, are very rare.

\* This blue urine was most probably caused by the presence of some vegetable colouring matter, more or less modified by passing through the kidney.

Prussian blue has also been observed as a precipitate in urine, but always, I believe, in cases in which iron, in some form, had been exhibited internally.\*

ON THOSE DISEASED CONDITIONS OF URINE NOT NECESSARILY  
CAUSING SEDIMENTARY DEPOSITS.

There are such considerable variations occurring in the proportions of the ingredients of urine voided at different periods of the day, that it is exceedingly difficult to draw a determinate line, as to what shall be considered a healthy or morbid proportion of any single constituent of the fluid. There are, however, excessive cases of variation which claim our attention. If it be the wish of the physician to note such deviations of proportion, he can accomplish his object by making the quantitative analysis as for healthy urine.

When, however, the secretion becomes admixed with matters foreign to its healthy constitution, we must employ a method of quantitative analysis very different from that applicable to healthy urine.

I shall proceed to describe the examination of urine by re-agents, both for the detection of an excess of any ingredient, or for the discovery of any principle not met with in healthy urine.

There are many medicines and vegetable colouring matters that are to be detected in the urine of those who may be using such, either medicinally or as articles of diet; and as these are apt to perplex the inquirer in his observations on the diseased or even healthy fluid, I shall append to the examination by re-agents a short account of such re-actions as are displayed by various matters foreign to urine in a pure state. I shall, lastly, notice the quantitative analysis of diseased urine.

ON THE USE OF RE-AGENTS IN THE EXAMINATION OF URINE.

*Nitric Acid.*—1. This re-agent is exceedingly useful in the discovery of albumen. If a few drops be added to

\* The microscopical figures of the urinary sediments are given at the commencement of the work.

urine containing that principle, we have a precipitate produced of a dead white colour.

2. This re-agent is also used to discover whether the urine contain lithic acid; but some hours are generally necessary for the production of this precipitate, which, if it fall in small quantity, is found adherent to the sides of the vessel used for experiment.\*

3. The colouring matter of the bile (which exists in solution as well as in the form of a sediment) is precipitated from the urine by this re-agent: the precipitate is of a green colour; but if an excess of nitric acid be added, it is quickly changed to a dingy red, and, finally, to a brown.†

4. When any great excess of urea exists in the urine, it is easily detected by placing a portion of the fluid in a watch-glass, and adding to it an equal bulk of nitric acid, which (if urea be present in a large proportion) will produce a speedy crystallisation of nitrate of urea. This test was first introduced by Prout, but it requires care in its application; because the heat of the atmosphere, being subject to variation, will cause an equal variation in the time required for crystallisation, even in identical specimens of urine.

Prout states, that when the specific gravity of urine is above 1.025 or 1.030, this crystallisation is frequently observed: but it is certain that a much higher specific gravity may exist without the urine possessing the property of becoming crystallised with nitric acid before evaporation; for Berzelius examined a specimen of urine of specific gravity 1.030, which, even when evaporated to three-fourths its original bulk, failed to yield crystals on the addition of nitric acid. This test requires attention to the atmospheric

\* In some fevers, the addition of nitric acid to the urine produces a large precipitate of lithic acid, and that of so white a colour that it closely simulates albumen. It may be distinguished, however, by being produced equally by the addition of hydrochloric acid, which is not the case with albumen.

† This re-action does not take effect unless a considerable proportion of colouring matter be present. If it be required to detect minuter proportions, we must evaporate the urine to dryness, and boil anhydrous alcohol on the extract. This alcoholic solution contains the colouring matter; and by evaporation we can procure it, and then detect its presence by nitric acid, as above described.

temperature ; and also a practical knowledge of the effects produced upon healthy urine by nitric acid, an equal bulk of the latter being always used in testing.

*Solution of Caustic Ammonia.*—The proportion of earthy phosphates may be ascertained by the addition of this reagent. A white precipitate is formed, which may be collected and washed on a filter with distilled water. The precipitate consists of phosphate of lime and magnesia with ammonia.

*Solution of Ferrocyanuret of Potassium.*—This is a very delicate test of albumen in urine ; but always requires the previous addition of a few drops of pure acetic acid.

*Solution of Alum* causes a white precipitate in urine containing albumen.\*

*Hydrochloric Acid*, like nitric acid, precipitates the lithic acid from urine, as also the colouring matter of bile ; and is rather to be preferred, since it is less likely to exert a solvent action on the lithic acid, and likewise preserves the characteristic green colour of the biliary matter, which the nitric acid soon changes to brown, if any excess of the acid be present.

*Turmeric Paper* changes from yellow to brown if moistened with alkaline urine, acid fluid exerting no re-action upon it.

*Litmus Paper (blue.)*—This is used to test the urine for acidity, being changed to a red colour if moistened with an acid specimen. Alkaline urine has no re-action on this paper.

*Solution of caustic potash*, boiled with an equal bulk of urine, is an excellent test for the presence of sugar, rendering the mixture of a dark rich brown colour if that principle be present. This test was proposed by Mr. Moore.

\* If albuminous urine be boiled, we have coagulation produced, which is very significant of the presence of albumen : but nitric acid should be used as a test in conjunction with ebullition ; for the earthy phosphates are sometimes precipitated by boiling, and become a source of fallacy. It has often occurred to me, to prove the phosphates present when the precipitate procured by boiling was considered albuminous.

## EXTRANEOUS PRINCIPLES IN URINE.

The urine frequently presents the various odours and colours of vegetable matters which have been taken into the stomach; and the examiner must be on his guard against being deceived by such appearances. Thus, I have known a patient on the point of being treated for hæmaturia, when the urine falling under my observation, I discovered the red coloration to proceed from the presence of a vegetable matter. On inquiry, the patient stated that he had been eating a salad, of which beetroot was an ingredient, during the last eight or ten days of his medical friend's visits.

I have also had occasion to observe the production of a deep brownish colour in the urine when vegetable infusions have been administered as medicines. This is almost always the case when the *pyrola umbellata* has been exhibited.

These vegetable colouring matters are at once distinguished by adding a solution of caustic potash to the tintured urine, when a green colour is produced, which is destroyed on super-saturating the alkali with an acid, the original tint being restored.\*

*Tannin*, which exists in many vegetable matters used as remedial agents, is capable of entering the urine. In this case we find the fluid strikes a dark colour with per-salts of iron.

*Mercury* has been said to exist in the urine of those who use frictions with mercurial ointments. This observation was made by Cantu, who obtained metallic globules from a sediment. I had occasion to examine the urine of a person who was salivated from large doses of calomel, but could not discover any trace of mercury in it. Arsenic and antimony have also been detected by Orfila in the urine of poisoned persons.

*Iodine* always exists in the urine of those who take it in-

\* In a case of poisoning by sumach, which lately came under my notice at Guy's Hospital, I found the urine highly impregnated with vegetable colouring matter.



ternally. I detected it in the urine of an individual who had taken only one grain of the remedy, and that in three separate doses of one third of a grain each. The process for the detection of iodine in urine is the following :—

A portion of the suspected fluid is evaporated to dryness over a water-bath, and the residue re-dissolved in a small quantity of distilled water.

This solution must be filtered, and treated with about one eighth part of strong sulphuric acid. If a solution of starch now be added to the liquor, we shall observe a fine blue colour if iodine be present. This colour is sometimes to be heightened by the careful addition of chlorine water, *guttatim*. Iodine is frequently to be detected in urine, simply by mixing that fluid with the above-mentioned proportion of strong sulphuric acid, and then suspending over the containing vessel a piece of bibulous paper, which has had a solution of starch dried upon it. In this way the fumes rise, and, combining with the starch, form the deep blue so characteristic of iodine in a free state.\*

*Tartaric, Citric, and Malic Acids* have been observed in the urine in combination with lime; they then exist as a deposit. The method of distinguishing these will be given in the Appendix.

Having now noticed the method of detecting the presence of various matters which are foreign to the healthy urine, I shall proceed to describe the means best adapted for performing the quantitative analysis of two very common forms of diseased urine, viz. the albuminous and saccharine.

#### QUANTITATIVE ANALYSIS OF ALBUMINOUS URINE.

It is requisite in this examination to use a distinct portion of urine, in order to ascertain the quantity of urea which may be present. In this form of diseased urine we frequently find that principle in an exceedingly minute proportion, and it is consequently very liable to escape obser-

\* I once digested alcohol on an extract of urine containing iodine in combination; but the alcoholic solution which I procured yielded no evidence of that body, when tested as above. This seems to show that in the urine the salt containing iodine is not an iodide, but probably an iodate.

vation. The urine for analysis is therefore divided into two portions, of equal weight.

*First Portion.*—This is accurately weighed, and then evaporated to dryness over an open steam-bath, and the residue treated with boiling alcohol, specific gravity 0·833. The alcoholic solution is now to be evaporated, and the extract so obtained redissolved in distilled water.

This aqueous solution is concentrated until it assumes the consistence of a syrup. It is then to be mixed with half its bulk of pure nitric acid, and placed in a freezing mixture capable of lowering the temperature to 32° Fahrenheit.\* By this means we produce a crystallisation of the nitrate of urea, and we can then abstract the crystals, which are to be treated as described in the article on the analysis of diseased blood, page 36., in order to ascertain the proportion of urea.

*Second Portion.*—This is to be weighed, and then evaporated to dryness; the weight of the extract being ascertained, we are enabled to determine the proportion of water by subtracting the weight of extract from the original weight of the fluid. This extract is now to be treated with boiling distilled water, and the mass thrown on a filter; the insoluble portion (consisting of albumen, lithic acid, earthy phosphate, and vesical mucus) is to be washed with warm distilled water, until that fluid exerts no further solvent action. This may be ascertained by occasionally testing the percolating fluid with nitrate of silver, which, if it do not affect the liquid, shows that the washings have been sufficient.† We thus procure a filtered liquor A, and a residue B.

A. The filtered liquor is evaporated to dryness and weighed; its weight being ascertained, it is next incinerated in a platinum capsule, over a circular-wicked lamp, until all the organic matter is dissipated. The weight of the decar-

\* Such a freezing mixture is easily made, by keeping a mixture in readiness composed of equal weights of nitre and sal ammoniac; two and a half ounces of which, when mixed with one fourth of a pint of water, produce the effect required.

† The extract should be quite dry before we add the boiling water, otherwise a portion of albumen will always remain in the filtered solution.

bonized salts may now be taken; and by subtracting this from the weight of the extract from the filtered liquor, we obtain the weight of ammoniacal salts, animal extractive, and urea together: but as the weight of the latter is already known, we can, by subtracting, determine the exact weight of the animal extractive and ammoniacal salts. Thus, we have already ascertained the proportions of

Water	-	-	-	-	-
Urea	-	-	-	-	-
Animal extractives, lactic acid, and ammoni-	-	-	-	-	}
acal salts					
Alkaline sulphates, phosphates, and chlo-	-	-	-	-	}
rides					

In order to finish the formula, we must now determine the proportions of albumen, lithic acid, and earthy phosphates, which is performed with the residue B.

The mass is removed from the filter, and its proportion deduced from our previous knowledge of the weight of the extract of urine, and also the weight of the matters contained in the filtered solution: by subtracting the latter from the former, we obtain the weight of the residue B as a result. Nitric acid, diluted with about six times its bulk of water, is now poured on the albuminous mass, and gentle heat applied for about fifteen seconds. The acid must then be poured off, evaporated to dryness\*, and incinerated; the weight of the result now indicates the proportion of earthy phosphate, which, if subtracted from the weight of the albuminous mass, gives us the weight of the albumen and lithic acid together. By this process then we have executed the following formula:—

\* Lithic acid, if present, can be detected during this evaporation by its re-action with nitric acid. It is not always to be satisfactorily discovered in these cases of albuminous urine. I have always in these examinations obtained an especial result for determining the proportion of the lithic acid by using for the purpose a portion of urine deprived of its albumen by boiling, then evaporating to a quarter's bulk, and adding hydrochloric acid as a precipitant, which throws down the lithic acid after a few hours.

Water	-	-	-	-	-
Urea	-	-	-	-	-
Animal extractives, lactic acid, and am-	-	-	-	-	}
niacal salts					
Albumen, with lithic acid and vesical	-	-	-	-	}
mucus					
Alkaline sulphate, phosphate, and chlo-	-	-	-	-	}
ride					
Earthy phosphate*	-	-	-	-	-

## QUANTITATIVE ANALYSIS OF URINE CONTAINING SUGAR.

The great difficulty to be overcome in this examination is that of determining the proportion of urea; for the sugar with which it is admixed completely prevents the crystallization on the addition of nitric acid. There seems little doubt that many specimens of diabetic urine have been stated to contain no urea, when that principle has been present in considerable quantity. Mr. Kane made some experiments on this subject, from which he concluded that urea is voided by diabetic patients in the same quantity per diem as by healthy individuals. His method of detection was by plunging the fluid, mixed with nitric acid, into a freezing mixture, formed with ice and common salt; at this temperature a crystallization of nitrate of urea occurred.

In this examination it is best to divide the urine into three portions of equal weight.

*First Portion.*—This, after being weighed, is evaporated to dryness over a steam-bath; the dry residue is then to be treated with boiling alcohol, specific gravity  $\cdot 833$  until it exerts no further solvent action.

This alcoholic solution, after filtration, is evaporated to dryness, and then re-dissolved in distilled water. The aqueous solution is now evaporated to the consistence of a thin syrup, and plunged into a freezing mixture,† where it

\* There is a variety of urine called by Prout chylo-serous urine. It contains a large quantity of fats in suspension. This urine may be cleared of fatty matter by agitation with ether, and then examined for other ingredients in the same manner as albuminous urine.

† That of ice and common salt is better for this experiment than the nitre and sal ammoniac before mentioned; but if ice cannot be procured, the salts must be substituted. For further account of this urine vide Appendix.

is to be mixed with its own bulk of a solution in equal parts of pure nitric acid and water. Crystallization will now occur if urea be present; and in this way it may be presumed that we can remove nearly the whole of the principle. It is, however, but fair to mention in our analysis, that a portion of urea probably exists in combination with the diabetic sugar. The nitrate of urea obtained as above must be treated in the same manner as that from healthy urine, in order to ascertain the proportion of urea present.

*Second Portion.*—This must be carefully weighed, and then evaporated to dryness; in this way we can ascertain the weight of water and solid extract. The extract is now to be treated with boiling water, which dissolves nearly the whole, leaving only a small residue of vesical mucus and earthy phosphate.

The weight of this residue being taken, we can by incineration determine the proportion of the phosphate (as a result) and vesical mucus (as the loss by incineration.) The aqueous solution is now to be evaporated to dryness, and the weight of the extract taken.\*

This mass is to be incinerated and decarbonised in a platinum crucible, when the weight of the residue is that of the salts, and the loss of weight by incineration minus that of the urea gives exactly the proportion of animal extractives, lactic acid, lactate of ammonia, and sugar. Thus, we can fulfil the following formula:—

Water	-	-	-	-	-
Urea -	-	-	-	-	-
Animal extractive, lactic acid, lactate of ammonia, and diabetic sugar, with probably a small portion of urea in admixture -	}				
Salts of incineration	{ Alkaline, sulphate, phosphate, chloride }				
Earthy phosphate	-	-	-	-	-
Vesical mucus	{ With perhaps a trace of lithic acid - }				

*Third Portion.*—This is to be used for the purpose of determining the weight of sugar present, which is done by

\* This weight might be deduced; but in all these experiments we can scarcely weigh too often.

pouring it into a retort in admixture with a small proportion of yeast, and placing the nozzle of the retort under an inverted and graduated jar filled with mercury. In this manner we can collect the carbonic acid produced by the fermentation of the sugar, and may estimate its quantity at a grain for every cubic inch of gas produced. This mode of calculating will be found sufficiently accurate for all practical purposes.

The weight of the sugar being ascertained, we may now subtract it from the other matters soluble in alcohol, with which it is mentioned in the formula, and it may be entered as a separate constituent in the analysis.



## ANALYSIS OF URINARY CALCULI.

THE examination of urinary calculi is very easily performed. We may divide the substances entering into their composition into two classes.

Firstly, those whose texture and composition become destroyed by a red heat; and, secondly, those capable of resisting heat, and whose composition remains unaltered after the action of that agent.

The first class contains the following substances: viz.

Lithic acid.

Lithate of ammonia.

Oxalic acid (existing as oxalate.)

Albuminous animal matter.

Dried blood.

Cystine, or cystic oxide.

Xanthic oxide.

Fibrinous calculus.

Ammonia (separated from phosphate of magnesia.)

The second class is not quite so numerous; containing as follows:—

Phosphate of lime.

Phosphate of magnesia.

Carbonate of soda (resulting from heating the lithate.)

Carbonate of lime.

Carbonate of lime, mixed with caustic lime (resulting from the decomposition of oxalate and lithate of lime by heat.)

Silica.

We sometimes find that lithic acid exists in combination with magnesia, but this is generally in an exceedingly small proportion. I have therefore abstained from mentioning it in the list of constituents.

I shall now proceed to describe the properties of each constituent, in the order observed in the list, commencing with the lithic acid. I shall then go through each step in

the analysis of a calculus compounded of all the substances ordinarily contained in urinary concretions.

CLASS I.—THOSE CONSTITUENTS OF URINARY CALCULI WHICH ARE DESTRUCTIBLE BY A RED HEAT.

*Lithic Acid.*

This form of calculus is more commonly met with than any other; it is generally of a yellowish-brown colour, and smooth on the surface: the brown coloration is owing to an admixture of animal matter, since the lithic acid, when pure, is perfectly white.\* We usually find that calculi of this description are formed of very distinct concentric layers. Lithate of ammonia, soda, or potash occur, mixed with this form of concretion; and the lithate of lime has also been observed.

The following are the chemical properties of lithic acid:—  
It is insoluble in water.

It is easily soluble in a solution of caustic potassa, and is precipitated from this menstruum by the addition of an acid, in a granular and colourless state.

It is dissolved by nitric acid with effervescence; and, by careful evaporation to dryness, yields a red or rather pink colour,† which becomes of a fine violet tint when ammonia is dropped on it, or even when it is subjected to the action of strong ammoniacal fumes. This reaction of ammonia is very useful, inasmuch as it prevents the yellow stain which many animal matters produce with nitric acid from being mistaken for the re-action of lithic acid. In the former case, the ammonia increases the yellow tinge to an orange colour, which is very distinct from the violet tint of murexid.

Before the blowpipe this substance emits a fetid smell of burnt horn, mixed with an odour approaching to that of hydrocyanic acid.

\* It has been said that lithic acid never occurs in its pure state in urinary calculi. This is what we should expect; but I once met with a calculus, the nucleus of which was composed of colourless lithic acid.

† Owing to the formation of murexid.

*Lithate of Ammonia.*

This substance has several times been observed forming whole calculi; these, however, are generally small; they are of a clay colour, with a smooth external surface. Their fracture is more earthy than that of the lithic acid variety.

Though it is very rarely that we meet with a calculus formed entirely of lithate of ammonia, yet a large majority of calculi contain that lithate in small proportions. Its properties are as follows:—

It is very soluble in boiling water, but much less so in that fluid when cold.

It is soluble in the solutions of alkaline carbonates.

With nitric acid it reacts in the same manner as lithic acid.

When suddenly heated on platina foil, it crepitates strongly.

When treated with potash, it yields vapours of ammonia.

The solubility of this substance in boiling water and solutions of alkaline carbonates sufficiently distinguishes it from the lithic acid.

*Oxalic Acid.*

This acid always exists as oxalate in urinary concretions; and the oxalate of lime is the only combination that has yet been detected in them. Calculi composed of oxalate of lime, either entirely or in great part, are of very frequent occurrence, and form the variety known by the name of the mulberry calculus, in consequence of its tuberculated exterior, presenting the appearance of that fruit. These calculi are generally of a dark brown colour. When sawn through and polished on the internal surface, we perceive an internal arrangement much resembling that of the fortification-agate, owing to a succession of conformable deposits taking place on the originally tuberculated surface. The chemical properties of oxalate of lime are as follows:—

It is insoluble in cold nitric and hydrochloric acids, but dissolves when boiled with these acids in a concentrated state; by long digestion, however, in cold hydrochloric acid, the powdered calculus becomes dissolved.

When boiled with a solution of carbonate of potash, it becomes decomposed, forming carbonate of lime and oxalate of potash.

Before the blowpipe, on platinum foil, this calculus becomes charred, emits a fetid smell (caused by decomposing animal matter ;) and if the heat be continued, a white ash remains, possessing an alkaline reaction, and capable of effervescing with the acids, owing to the formation of a portion of carbonate of lime, varying in quantity according to the heat employed for calcination: the alkaline reaction above mentioned is attributable to the presence of caustic lime.

This variety of calculus is easily distinguishable by the fact of its effervescing in dilute acids after calcination, and its insolubility and refractory character, previous to the application of heat.

We occasionally meet with a form of the oxalate of lime calculus, the external surface of which is perfectly smooth and polished. These calculi are very small; seldom more than half the size of an almond, of an oval form, and known as the hemp-seed calculus. I have examined but one specimen of this variety of concretion.

Calculi occasionally occur, having their surfaces studded with octahedral crystals of oxalate of lime. I first published an account of such a calculus with a description of the crystals, in the Guy's Hospital Reports for October, 1837. Dr. Bird has since described octahedral crystals of oxalate of lime as occurring in the urine—these insoluble octahedra had been before noticed by Vigla, but not described as the oxalate.

### *Albuminous Animal Matter and dried Blood.*

The former of these is constantly present, in greater or less proportion, in every kind of calculus. It exists in considerable quantity in calculi composed of lithic acid or the phosphates.

It has been a matter of doubt whether the deeper tints of colour observed in calculi be not owing to some form of animal matter distinct from dried blood, and though it is not very easy to form an opinion by the examination of

these matters, as presented to us in calculi, I feel pretty confident that blood is the only colouring matter capable of producing the deep tints observed in many varieties of calculus.

There is also a peculiarity of colour, which a practised eye immediately seems to recognise as the appearance put on by blood coagulated by heat; and I would beg the reader, on the first opportunity, to boil some diluted serum with red particles in admixture, when he will find that, according to the quantity of red particles present, he can produce modifications of colour exactly resembling those observed in the varieties of dark-coloured calculi. To this we may add, that from some calculi possessing such a colour, we can extract hæmotosine from the external layers.

The albuminous animal matter contained in calculi has the following characters:—

It is insoluble both in cold and boiling water.

When treated with a solution of caustic potassa it dissolves, but may be precipitated from this alkaline menstruum by means of hydrochloric acid. It produces a fine yellow colour when boiled with nitric acid, and yields all the well-known re-actions of albumen.

### *Cystine, or Cystic Oxide.*

We are indebted to Wollaston for the discovery of this substance. It is of rare occurrence in the human species, but is frequently met with in the dog. The larger kind (of which there is a beautiful specimen in the museum of Guy's Hospital) is semi-crystalline, and not unlike stearine in appearance; there is a slight greenish tinge, and a radiated texture of a very peculiar character, observable throughout its section. The smaller kind (as those met with in the dog) are not distinctly crystalline, but solid and compact, and frequently want the greenish tinge peculiar to the larger and apparently more completely formed variety. Wollaston's reason for giving the name of cystic oxide to this substance was, that he considered it peculiar to the bladder. This, however, is not the case; for it has been observed in the kidney by Dr. Marcet. Dr. W. chose to call it an oxide, because it resembled some few of that class of sub-

stances in being soluble in both acids and alkalies, the term cystine is however more appropriate. Cystine exists in calculi in a perfectly pure form ; the only compound calculus, containing cystine as a constituent, is contained in the collection of Guy's Hospital.

It may be procured in crystals, by allowing its solution in caustic ammonia to evaporate spontaneously. We can then observe the crystalline form to be that of flattened hexagonal prisms. Its chemical properties are as follows:—

It dissolves in dilute nitric, hydrochloric, sulphuric, oxalic, and phosphoric acids ; but will not combine with the tartaric, acetic, or citric acids.

It is dissolved by caustic ammonia ; but not by the carbonate of that alkali.

The fixed caustic alkalies, as also their carbonates, readily dissolve it.

When nitric acid is evaporated on cystine, a dark-brown colour is produced.

It is insoluble in alcohol ; and water exerts but a feeble solvent action.

If it is wished to precipitate cystine from its solution in acids, the carbonate of ammonia is best for that purpose ; if from its solution in alkalies, the acetic acid is the best we can employ.

The following method of proving the presence of cystine has been proposed by Liebig :—Dissolve the calculous matter in caustic potassa, then add a solution of acetate of lead in such proportion that the oxide of lead shall not precipitate, but be retained in solution by the excess of potassa. This liquor becomes black when boiled if cystine is present,—a re-action dependent on the presence of sulphur in the cystine.

Before the blowpipe it is consumed, yielding a very peculiar fetid smell.

Cystine may easily be distinguished from the other components of calculi, by its being soluble in dilute hydrochloric acid, and also in the solution of carbonate of potash. Its very peculiar odour, when heated on platinum foil before the blowpipe, forms likewise a good distinguishing characteristic.



*Xanthic Oxide.*

This calculus was first observed by Dr. Marcet, and has since been noticed by other chemists. When reading the re-actions described by Dr. M., we recognise many of the characters of lithic acid. The action of nitric acid on xanthic oxide is what I have more than once had occasion to observe in lithic acid calculi containing much albuminous matter.\* Stromeyer found this substance in a calculus. The chemical characters described by Marcet as peculiar to this substance accord pretty completely with those of lithic acid, except in its affording a yellow colour when heated with nitric acid; which colour becomes changed to a reddish tint on being treated with potash.

Before the blowpipe this calculus decrepitates, and is said to give out a peculiar odour, unlike that of cystine or lithic acid; it leaves a slight ash when perfectly incinerated.

Professors Wöhler and Liebig have lately examined a specimen of this calculus. It is stated to differ from lithic acid in not yielding urea by ignition in a close tube, and by dissolving in nitric acid without evolution of gas.†

*Fibrinous Calculus.*

It has been before mentioned that every species of calculus (except, perhaps, that composed of cystine) contains an animal matter of an albuminoid character. The calculus now under consideration appears, however, to consist entirely of this substance.

\* In the seventh volume of the *Traité de Chimie* of Berzelius we find the following passage concerning the re-actions of the xanthic oxide:—"Sans vouloir prétendre que l'oxide xantique était simplement de l'acide urique, ou de l'urate ammonique, avec une matière animale qui modifiait la couleur de la dissolution nitrique évaporée, il paraît cependant qu'on ne pourra avec une entière certitude le considérer comme une matière particulière, que quand il aura été retrouvé et analysé de nouveau."

† A small fragment of the calculus examined by Liebig and Wöhler has been presented to the museum of Guy's Hospital by Dr. Willis.

It was first noticed by Dr. Marcet, and its chemical characters resemble those of fibrin.

This calculus is said to approach yellow wax, both in colour and consistence; its structure being fibrous, and somewhat elastic. Its re-actions are as follows:—

It is insoluble in water, alcohol, and hydrochloric acid. When treated with a solution of caustic potash it dissolves, and may be precipitated from this solution by the addition of acid.

It dissolves in acetic acid by the assistance of heat; and this solution, like that of fibrin, may be precipitated by the solution of ferrocyanuret of potassium.

It is dissolved with difficulty by nitric acid. Before the blowpipe it gives out the smell of burnt horn, and leaves a bulky charcoal.

*Ammonia (separated from Phosphate of Magnesia.)*

It is very easy to determine whether ammonia be present in any specimen of calculous matter submitted to our notice; but the greatest care is requisite before we can determine whether that ammonia proceeds from the presence of the triple phosphate of ammonia and magnesia, or from the lithate of ammonia: this can often be accomplished by determining the absence of one of these bodies by other tests than those dependent on the presence of the volatile alkali. If ammonia can now be proved to exist, it shows the presence of the other constituent; but further than this the testing for ammonia is a useless step in the analysis of calculi. When we separate the lithate of ammonia by means of boiling water, the ammoniacal test is, however, valid as a proof of the nature of the two substances so separated.

Before, therefore, we can be sure that any ammonia which may be detected proceeds from the triple magnesian phosphate, it is necessary to wash the portion used for performing this test with a considerable excess of boiling distilled water, till the liquor ceases to yield the re-actions of lithic acid.

The testing for ammonia is performed as follows:—

A small portion of the calculus is placed on a piece of

platinum foil, and treated with carbonate of potash in a concentrated solution. Vapours of carbonate of ammonia are now evolved, which may be detected by their well-known odour; but the best method of proving their presence is by holding over them a rod which has been dipped in fuming hydrochloric acid, when fumes of hydrochlorate of ammonia will be distinctly visible. It is frequently recommended to use caustic potash instead of the carbonate in this experiment; but the former is very liable to form ammoniacal fumes by its peculiar action on a great variety of animal matters, and therefore is not so distinctive as the carbonated alkali.

CLASS II.—THOSE CONSTITUENTS OF URINARY CALCULI CAPABLE OF RESISTING THE ACTION OF HEAT.

### *Phosphate of Lime.*

This substance but rarely exists as the sole ingredient of a calculus; when it does so, the concretion is always very smooth and polished on the surface, and very distinctly laminated. It is generally of a pale-brown colour. Fourcroy and Vauquelin doubt much whether it ever occurs unmixed with the triple phosphate. The phosphate of lime is a very frequent ingredient in compounded calculi; and when united to the triple phosphate in considerable proportion, it forms the fusible calculus, so called from its easy fusibility before the blowpipe.

The chemical properties of the phosphate of lime calculus are the following:—

It is soluble in the dilute mineral acids, and precipitable from this solution on the addition of ammonia.\*

Its acid solution, when nearly neutralised by ammonia, and then tested with oxalate of ammonia, gives a precipitate of oxalate of lime.

Before the blowpipe it blackens, and leaves a copious white residue, if the heat be continued. It requires a very intense degree of heat for fusion.

\* This precipitate is in a gelatinous form, and very characteristic of the earthy phosphates.

This form of calculus is best distinguished by its negative properties. Thus, it is known from the triple phosphate by not yielding ammoniacal fumes when treated with potash; and from the fusible calculus by the great difficulty experienced in even rounding the edges of its fracture with the blowpipe flame.

*Phosphate of Magnesia (resulting from the triple Phosphate.)*

This salt, which remains as the result of heating the triple phosphate, was for a long time confounded with the phosphate of lime. It possesses the following chemical characters:—

It readily dissolves in the acids: even cold dilute acetic acid acts powerfully on it.

It cannot easily be fused by a blowpipe heat..

When oxalate of ammonia is added to its solution in acid, no precipitate is observable, which serves to distinguish it from the phosphate of lime. When these earthy salts occur together, they may be separated by a method which will be described in the process for the analysis of mixed calculi.

*Carbonate of Soda (resulting from heating the Lithate.)*

It may be known by its solubility in water, and alkaline re-action, as also by effervescing with acids: it occurs but in very minute proportion in urinary calculi; but the lithate forms the great bulk of gouty concretions occurring about the smaller joints, and it is also found very generally in the urinary deposits of rheumatic subjects. The carbonate of soda may be known from that of potash by its colouring the flame of the blowpipe of a fine yellow hue.

*Carbonate of Lime.*

This substance sometimes occurs as an ingredient of mixed calculi; but I do not know of any well-authenticated case in which it has been shown to exist alone as the constituent of a calculus from the human subject. When carbonate of lime is tested in a calculus, we must always

make our examination before any incinerating process has been had recourse to ; for by such a step we run the risk of forming a carbonate of lime (which did not originally exist in the calculus) by the decomposition of any oxalate or lithate of lime which may be present in the concretion. Since, however, neither oxalate or lithate of lime produce effervescence with acids, there is no danger of confusion when tests are applied prior to calcination.

If, then, calculous matter produces an effervescence on the addition of cold dilute hydrochloric acid, we may conclude that a carbonate is present.

The chemical properties of the carbonate are the following:—

It effervesces when moistened with cold dilute hydrochloric acid.

The solution in acids is precipitated on the addition of oxalate of ammonia ; care being taken previously nearly to neutralise the acid liquor.

It is insoluble in water.

*Carbonate of Lime mixed with Caustic Lime (resulting from the Decomposition of Oxalate of Lime by Heat.)*

It may always be known that this substance is the result of incinerating the oxalate of lime, if we find the matter subjected to examination capable of effervescing, only after incineration.\*

If a specimen of calculus matter effervesces both before and after incineration, then of course we may conclude that carbonate and oxalate of lime are both present ; provided we have taken care to extract all the carbonate by means of dilute hydrochloric acid (which must be well washed from the calculous matter previous to performing the incineration;) for the acid having removed all the carbonate, any

\* When lithate of lime exists in a calculus, we may have effervescence produced after incineration. When we have any suspicions, we should take care to employ a digestion with muriatic acid, previous to performing the calcination. When this precaution is used, we can be sure that any effervescence which may occur is caused by the decomposition of oxalate of lime.

which may be detected after calcination must be regarded as a result of that process.

### *Silica.*

This substance was twice detected by Vauquelin and Fourcroy during their laborious researches into the nature and composition of urinary concretions. Venables also reports the case of a woman who passed a calculus containing silica. It seems highly probable that this substance may exist in small proportion in most calculi; nor can we be surprised at its having been overlooked by those who examine the concretions; for, to do justice to such an investigation, it would be necessary to sacrifice the greater portion of most calculi which is seldom permitted to the chemist, since such minute investigation has rarely been a desideratum with those who subject their specimens to his operations.

Silica may be known by its perfect insolubility in water, and the concentrated mineral acids; and likewise by its forming transparent colourless glass, when fused with carbonate of soda on charcoal before the blowpipe.

Having now separately noticed each constituent of urinary calculi, I shall proceed to describe the method for determining the composition of a compound calculus, containing all the ingredients which are ordinarily met with in such a concretion;\* viz.

Lithic acid.

Lithate of ammonia.

Lithate of soda.

Lithate of Lime.

Oxalate of lime.

Ammoniaco-magnesian  
phosphate or triple  
phosphate.

Phosphate of lime.

Carbonate of lime.†

} Forming the fusible calculus, if the phosphate of lime be in sufficient proportion.

\* Calculi for examination should always be sawn through the centre, in order to expose the layers to view. A portion of each of these layers must be used to form the powder for analysis.

† Cystine, xanthic, and fibrinous oxide are here excluded, because



The portion of calculus intended for examination must be reduced to a fine powder, in a small agate mortar, and the powder divided into two parts.

*Treatment of first Part.*—This is placed in a small glass flask, and distilled water boiled upon it for several minutes.

The liquor is now to be poured off, and a few drops of it evaporated to dryness on a watch-glass; when, if there be any residue, we must again treat the powder in the flask with a fresh portion of distilled water, which is to be boiled as before, and tested for a residue.

This treatment is to be pursued until we no longer extract any thing with boiling water.\* Thus we procure an aqueous solution A, and a residue B.

A. The aqueous solutions are to be added together, evaporated to dryness, and the residue of the evaporation examined as follows:—

#### *Lithic acid.*

A portion is placed on a watch-glass, and treated first with nitric acid and then with ammonia, as before described, when we shall procure the characteristic re-action of lithic acid (this residue of the aqueous solution consisting of the lithates.) Having now tested the acid, our attention must be directed to the bases.

#### *Ammonia.*

A small portion of the residue is placed on a watch-glass, and moistened with a solution of caustic potash, when ammoniacal vapours will be produced, known by their characteristic odour, and also by testing them with fumes of hydrochloric acid, as before described.

#### *Soda.*

The remainder of the residue may now be carefully

they never exist in any considerable quantity as components of calculi. Several other matters, which appear rarely and in small proportion, are also omitted; such are silica and hydrochlorate of ammonia; the latter first noticed by Dr. Yellowley, in the Philosophical Transactions.

\* This soon happens, if we use each time a large bulk of water in proportion to the quantity of calculous matter.

heated on platinum foil at a low heat, when it will char, and partly volatilise. The remainder (if any exist,) when perfectly decarbonised, will possess an alkaline re-action. When cold distilled water is digested on it, we shall find a portion becomes dissolved, and the liquor so formed not being precipitable by the solution of an alkaline carbonate, we at once recognise the dissolved matter as a fixed alkali.

### *Lime.*

The matter which was not dissolved by the distilled water will be found to dissolve with effervescence in a drop of dilute hydrochloric acid, and to be precipitable from this acid on the addition of a solution of oxalate of ammonia: this precipitates lime.\* The aqueous solution contained then,—

Lithate of ammonia.

———— soda.

———— lime.

B. The calculous matter, insoluble in water, is now treated as follows:—

### *Lithic acid.*

A small portion is tested for lithic acid, with nitric acid and ammonia.

### *Carbonate of lime.*

A second portion is mixed with dilute hydrochloric acid; and if any effervescence occurs, we may conclude that carbonate of lime is present.

### *Oxalate of lime.*

The remaining matter insoluble in water is now to be digested in dilute hydrochloric acid, then incinerated and decarbonised in a platinum capsule, over the spirit lamp: the residue when cold is tested with dilute acid; and if effervescence occurs, we may conclude that carbonate of lime is present.

\* It must be observed, that this result of incineration on platinum foil is always minute, and great care is requisite in adding the water, to dissolve out the carbonate of soda, as well as in the addition of acid to the lime: a drop of dilute acid being quite enough for the latter purpose, and the same quantity of the test being quite sufficient as a precipitant for the lime.

vescence ensue, we may be sure that oxalate of lime is a component of the calculus.\*

*Treatment of second Part.*—This is to be placed in a platinum capsule over the spirit lamp, and perfectly incinerated and decarbonised.

Should carbonate of lime be present in this result of incineration (which of course is the case when the carbonate or oxalate of that earth exist in the calculus,) we must dissolve the whole in dilute hydrochloric acid, and precipitate the solution with caustic ammonia, by which means we throw down the phosphates only which may exist in the liquor. This precipitate is to be placed on a filter, and washed with cold distilled water; it must be dried, and then is ready for examination.†.

### *Phosphates.*

A small portion is placed on the end of a platinum wire, which must previously be curled into a small noose, in order to hold more of the matter for experiment. The flame of the blowpipe must now be carefully directed on the mass; when, if fusion occur quickly on urging the heat to incipient whiteness, we may conclude that we are operating on the phosphates of lime and magnesia in the proportions constituting the fusible calculus. If no fusion occur, we must have recourse to other proof, in order to show that these two phosphates are present, which is often the case though they be not in the proportions necessary to form the fusible compound. This extra proof of their presence may always be recurred to if we wish for any corroboration on the subject. The examination is as follows:—

\* The reason for using a digestion with hydrochloric acid is to extract all the carbonate of lime before incineration is performed: by which means we may be sure that any which appears after incineration is the result of decomposed oxalate.

† If no carbonate or oxalate of lime exists in the calculus, then we may at once proceed with the examination of the result of incineration, without using the solution in hydrochloric acid and precipitation with ammonia, which is otherwise necessary in order to separate the phosphates.

*Phosphoric Acid.*

The incinerated or dried mass is to be dissolved in dilute and pure nitric acid, and the solution divided into two portions. One is tested with nitrate of silver, which produces a yellow precipitate on neutralising the excess of acid in the solution by the addition of an alkali. This precipitate is phosphate of silver, and thus we prove the presence of phosphoric acid.

*Lime.*

The second part of the solution is to be nearly neutralised with ammonia,\* and then a solution of oxalate of ammonia added, which will precipitate lime after a short interval has elapsed.

*Magnesia.*

The precipitate (which is oxalate of lime) is allowed to subside, and the clear liquor poured off. This, when tested with caustic ammonia, will produce a crystalline precipitate of triple phosphate, if magnesia be present. It is very seldom that we have calculi presented for examination containing so many ingredients as the one here noticed. Very frequently we cannot extract any thing from the mass by means of boiling water, and then it may at once be concluded that the lithates are absent. Indeed, when we procure a residue by evaporation from the boiling aqueous solution, we shall continually find that it consists of lithate of ammonia only, and is entirely volatilised when heated on platinum foil. Again, we but seldom encounter the carbonate of lime in these researches, and this renders the determination of the oxalate of lime more simple and satisfactory. It is not at all uncommon to meet with calculi that are entirely dissipated on the application of heat. When this is the case, our examination is much simplified; for we can exclude from the possible list of constituents the triple

\* The solution should, however, always be slightly acid, in order to preserve the magnesia in solution till the lime is precipitated, and the liquor should be well boiled, in order completely to get down the precipitate of oxalate of lime thrown down by the oxalate of ammonia.

phosphate, phosphate of lime, oxalate and carbonate of lime: thus but few matters are left for our consideration. These destructible calculi consist for the most part of lithic acid, combined with more or less of the lithate of ammonia. When a calculus consists of the earthy phosphates, in a tolerably pure state, we find that it blackens before the blowpipe, owing to the presence of vesical mucus. When incinerating such a specimen, we cannot be sure but that this carbonisation is owing to the presence of lithic acid. The effect of the blowpipe, therefore, though of considerable assistance as a test, in cases where all the calculous ingredients are volatile, cannot expedite our analysis if a residue be obtained after its incinerating action.

I would advise those who analyse calculi to commence their examinations by incinerating a small portion on platinum foil; when, if no residue be observed, they much simplify their labours—as they can be sure that no earthy or fixed alkaline salt exists in the concretion.

It frequently happens that calculi are given to the chemist for examination, consisting of different layers of considerable thickness, and it is required to know the constitution of each separate formation. When this is the case, it generally becomes necessary to examine a portion of each layer, according to the process described above; for though we may have examined a powder formed from triturating a portion of the layers, yet we cannot always determine which of these has yielded any one or more of the constituents of the whole calculus.

In conclusion, I may observe, that when we are extracting portions for examination from the different layers of a calculus, it is very necessary to avoid turning over and shaking the sawn surface, in order to dislodge the fragment which we have detached; for by so doing we are very likely to admix portions of the other layers if they happen to be friable, as is often the case. The best way of avoiding this source of error is to pick up the detached portion for examination, by means of a thin glass rod, moistened with distilled water, to which the calculus matter readily attaches itself, and can thus be removed for experiment.

ON THE  
TREATMENT  
OF  
URINARY DISEASES.





ON THE  
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IN presenting the reader with the following essay on urinary diseases, my object has been to describe as concisely as possible the ordinary features of each class of affection, to enter upon a consideration of the most approved methods of treatment, and to add the results of my own experience on several parts of the subject. On some points of practice I have been led to form opinions materially affecting treatment, and not entirely devoid of novelty. I therefore venture to hope, that this contribution to the literature of the subject may contain matter of interest, if not of advantage, to the reader.

ON THE LITHIC DEPOSITS.

Urine depositing the crystalline red gravel is generally of fine deep yellow colour, and contains an excess of acid. Its specific gravity will in most cases be found to exceed that of health, varying from 1022 to 1025, or even higher. When viewed under the microscope, this deposit presents a crystalline texture, and is seen under various forms. (Vide plate, figure 3.) It yields all the re-actions of lithic acid when chemically examined. (Vide p. 73.)

The symptoms observed in those who suffer from the crystalline lithic acid deposit are occasionally of a very severe character, and are constantly brought before the attention of practitioners as occurring among those members of every class of society who either from idleness or necessity fail to take the regular exercise indispensable to the preservation of health, and who at the same time may have the opportunity of indulging freely in animal food, either with or without the use of spirituous drinks. The tendency to the formation of lithic acid deposit is frequently marked by a liability to sharp lancinating pains affecting the extremities, and by lumbar pains combined with a certain degree of irritation experienced during micturition. These symptoms are seldom observed when the lateritious sediments composed of the lithates are being excreted by the patient, except of course when they occur in fever, rheumatism, or gouty disease, and not as constituting an unmixed variety of urinary affection. When transient but sharp pains are experienced by the patient, and any complaint is made of scalding or irritation after micturition, while no other prominent symptom of constitutional disturbance is to be observed, we may very generally conclude that any deposit found in the urine will be composed of crystalline lithic acid, and not the lateritious sediment. The two causes of distress above alluded to constantly exist together as symptoms indicative of a tendency to lithic acid deposit, and that too when the general functions of the body are for the most part regularly discharged, and the general tone of the system preserved in a manner not to be observed in any other form of urinary disease attended with pain.

It is true that such patients complain frequently of dyspeptic symptoms; but these for the most part are of trivial character, and by no means approaching the importance of those characterising the phosphate and oxalic forms of deposit, in which we constantly observe an irritability and lassitude in connexion with dyspepsia which render the patient either unwilling or unable to enter upon the ordinary avocations of life, and, when obliged to use exertion from necessity, injured and not benefitted by the effort.

The lithic acid deposit either in the crystalline or agglutinated form is generally a disease of the middle or advan-

ced stages of life, and when occurring in youth or infancy seldom fails to indicate a tendency to grave disease. The liability to calculus is frequently shown by the occurrence of lithic acid deposit in childhood, and a gouty tendency is often indicated in the same manner. In youth, the lithic acid deposit is sometimes observed in connexion with Morbus Brightii.

I have known the lithic acid to exist in the urine of a child hereditarily predisposed to gout, and eventually lead to the formation of calculus in the bladder, which being passed by the urethra at an early period of its formation, thus for a short time relieved the sufferer. This patient, however, subsequently became the subject of gout in a severe form, but never afterwards experienced a return of calculous symptoms. As regards the formation of lithic acid calculi, it is chiefly at a more advanced age that the deposit is found in the urine in a form threatening their production. Thus the deposit, instead of appearing at the bottom of the chamber vessel as a crisp crystalline sand, is observed to assume a more rounded form, each little mass being more or less circular, and adhering occasionally to the bottom of the vessel even when the urine is shaken over it with some degree of rapidity.

Dr. Prout has stated, as a general rule, that it is in middle life that the deposit of lithic acid assumes this concrete form, threatening calculus of the kidney or bladder. The *crystalline* lithic deposit, however, is not at all uncommon in middle life; I have met with several such cases showing its presence. Where the concrete form exists, of course there will be an increased tendency to the formation of calculus. I never saw, however, the *concrete* lithic acid deposit in a child, and believe it rarely if ever to exist.

In old age, a tendency to the excretion of very small rounded lithic acid calculi is sometimes observed. Dr. Prout has particularly noticed this condition of urinary disease, which appears connected, in general, with mischief in the urinary passages, and a tendency to the secretion of alkaline urine.

#### *Deposit of Lithates (Lateritious Deposits.)*

This form of deposit, formed of lithic acid in combination with ammonia, lime, magnesia, or soda, presents under the

microscope the appearances described by figures 4, 5, and 6. (Vide plate.) Examined chemically, it yields the reactions described at pages 84, and 85. If urine containing the lithates be heated the whole deposit is immediately dissolved. The colours assumed by the various lithates, when existing as deposits, are indicative of certain conditions of system, and they become thus valuable guides to treatment. When a dusky nut-brown colour occurs, we may very generally infer that little else than an ordinary dyspeptic attack has supervened, and if the urine be in other respects of normal character, no great anxiety need be entertained on the subject. There is not, however, the same security in those forms of lateritious deposit characterised by a white or dark purple colour. When urine depositing the nut-brown sediment is not much above the normal specific gravity, (that is to say, not above from 1018 to 1022,) and when no evidence can be obtained of the presence of sugar, we shall seldom be wrong in attributing the attack to some accidental exposure or intemperance in diet; but it will sometimes happen, and that in cases in which other symptoms to countenance such a belief are entirely wanting, that traces of sugar can be detected in the urine, and then it becomes our duty carefully to investigate the case, and steadily to enforce treatment. It is not uncommon for persons, who have passed lithates for years without the supervision of any disagreeable symptom, suddenly to become the subjects of dyspepsia, attended with thirst, and then, on applying to their medical attendant, to doubt the possibility of any mischief having arisen from neglect of a symptom to which they have become, as it were, habituated; nor is it uncommon to learn from them that they never feel so well as when excreting the deposit in large quantity. It is only when this form of deposit is associated with a saccharine condition of urine, that it becomes of importance as a disease, and it is always well to be sure of the absence of sugar in the secretion before we promise the patient that certain and immediate relief, which we need seldom fail to afford in the uncomplicated form of dyspepsia, leading to the deposition of brown lithates as a sediment. Dr. Prout remarks, when treating of this subject, that the tendency to the deposit of lithic sediments is almost invariably connected

with hæmotrophy of the kidney. Now it is true that we observe the lithic acid in the crystalline form, and the lithates also, occasionally appearing in the urine of those who are the subjects of albuminuria; but this is far from always the case, and again, the lithic acid and lithates are most decidedly found unconnected with a coagutable state of urine; so that I cannot well understand how the close connection spoken of by Dr. Prout can have presented itself to his mind, nor upon what grounds he has determined the presence of hæmotrophy in the cases to which he alludes. When the lithates deposit in the urine entirely devoid of colouring matter, and approach the white tint of the phosphates, it is not uncommon to observe dysuria as a symptom. I am far from considering with Dr. Prout, that this deposit is indicative of a tendency to deposit the phosphates, that is to say, if it be secreted pure, and entirely soluble in the urine when heated. The nut-brown deposit noticed above, I have, however, not uncommonly found alternating with the triple phosphate, which would tend to show that when these two deposits follow each other, the white lithates are not necessarily to be expected. The cause of this alternation of phosphatic with lithic deposit will be hereafter entered upon. The lithates, when excreted of a red or pink colour, are generally concomitants of a febrile condition, and disappear immediately the cause for constitutional disturbance (if it admit of remedy) is removed. In rheumatism and rheumatic gout, I have observed the red sediments to occur very frequently; and in a case of the kind recently under my care, I had an opportunity of witnessing their gradual change to a bright pink, while the urine assumed a dark purple colour, resembling that of murexid. In this case there had been long neglect of the bowels, and dyspepsia, while constipation formed an obstinate symptom throughout the course of the disease.

In cases such as that above described, it is not uncommon to find old visceral derangement; and provided rheumatism and gout do not appear as part of the disease, the appearance of the pink deposit must be regarded with anxiety. When, however, such symptoms are present we know they alone are occasionally capable of producing this urine with the pink deposits, and there is less cause to fear



the existence of deep-seated disease affecting the liver or other chylopoietic organs.

The red and pink sediments have been regarded as peculiar to fever, to the exclusion of the yellow amorphous sediment. I have observed the latter several times in typhus remittent. As a general rule, however, the red sediments are produced by the febrile state.

The treatment to which it is necessary to have recourse in these affections must vary according to the character assumed by each kind of deposit.

When the red crystalline form of lithic acid is excreted, it has been very commonly supposed that the chief benefit we can derive is to be expected from the administration of alkaline remedies, which are known to correct the acid state of urine found in connection with this form of disease, and, moreover, to act as solvents on the deposit itself. It is a matter of fact that alkaline remedies will constantly cause the urine of patients suffering from the lithic acid deposit to become clear and transparent, and that the symptoms of dysuria are generally relieved by the remedy; but I have seldom known this palliative treatment attended by any lasting benefit; and we must remember, that it should be our object to correct those general conditions of system on which the production of the unhealthy urine depends, rather than to afford a temporary benefit, by the use of means in themselves but ill calculated to effect the great object of all treatment.

It is true that in those forms of deposit having a tendency to agglutinate, and therefore threatening the formation of calculi, the use of alkaline remedies may be necessary for a short period, and should be used in virtue of their mechanical as well as chemical powers to rid the bladder and urinary passages of the irritation produced by adherence of the deposit; but it is not to the continuance of such treatment, that we are to look for relief even in this form of disease.

It has probably been matter of experience with most of those who met with cases of red deposit, before the chemistry of urine had received attention, that any remedy possessing the power of invigorating the system, improving the appetite, and relieving the sense of fulness and tendency

to sleep after meals, was capable of exerting a powerful controlling action over the excretion of lithic acid by the urine. The labours of animal chemists, however, produced so great a revolution in the minds of practitioners, that notwithstanding the force of prejudice (in our profession not generally so easily conquered,) the practitioners of our art almost universally adopted the opinions of those whose labours and results in the laboratory unfortunately assumed a complexion giving them an apparent right to dogmatise in physic; and the indiscriminate and mischievous use of alkaline remedies in cases of lithic disease is a prominent instance among the evils they were allowed to inflict. Apart from their use as mechanical agents acting through their solvent chemical power, I have good reason to discredit the production of benefit by their use, and they retard rather than expedite the good effects we can derive from the exhibition of other remedies. There are several forms of disease in which the elements of the urine appear to arrange themselves in an unusual manner; and the formation of urinary deposit, not only in those cases of disease in which it is formed by a natural constituent of urine, but even when a material foreign to health appears, would seem sometimes to depend rather upon this tendency, than to the secretion of a positive excess of the constituent in the one case, or the production by the blood of some unusual body in the other. In such instances it is that we are generally at a loss to comprehend the causes in the action competent to the production of the effect upon the urine; and though we may sometimes contrive, by the ingenious doubling and mingling of atoms, to extract a probable explanation by the transposition of elements, we are in no way assisted by this process to a better understanding either of the true nature of the disease or the plan of treatment best adapted to its cure. Although we derive but little assistance from chemistry, so far as the treatment of this form of disease is concerned, we yet have present a certain set of symptoms indicative of general constitutional disturbance, by treating which the urinary mischief admits of being alleviated.

The exhibition of mild aperients combined with alteratives at night, and the use of vegetable tonics administered at intervals during the day, will generally be found of im-

mediate efficacy in the cure of the disease in its early stages. When, however, the patient suffers from symptoms indicating a tendency to the formation of calculus, such as lumbar pains or sharp cutting sensations in the course of the ureters, it is well to combine our tonics with the liquor potassæ, or bicarbonate of potash, in moderate doses. From fifteen to twenty minims of the former, or ten to fifteen grains of the latter, will generally be found sufficient in most cases. It is well, however, and more especially in hypochondriacal persons of low power, gradually to omit the use of alkali on the disappearance of the pains. This is best done by substituting small doses of magnesia for a few days, after which all alkaline remedies may be set aside.

As regards the diet advisable in this form of disease, in early cases, there appears no objection to the use of any article known by experience to agree with the stomach of the patient. A careful regard to quantity is of course as valuable here as in every description of disease in which dyspepsia takes a prominent part. When long-continued inconvenience has been experienced from discharge of the lithic acid however, fish diet may be enjoined, with rest and perfect freedom from causes of irritation and anxiety during the hours of digestion.

The use of wine is objectionable; and in all cases, however mild, it is right to diminish the quantity to which the patient may have been accustomed, as an indispensable part of the treatment. Ripe fruits, which, from containing vegetable acids combined in excess with alkaline bases, yield alkaline carbonates to the blood and urine, are sometimes of use in cases characterised by the cutting pains of gravel; but, like alkaline remedies in general, are more valuable in the removal of immediate symptoms than as adjuvants in effecting a permanent cure. In simple cases of lithic deposit they are not needed; and as they are frequently productive of much evil by causing increased dyspepsia and much distress from flatus, it is generally better that they should be avoided. This same objection, and for the same reason, applies to acid wines and beer. When the patient passing lithic acid possesses a pulse indicative of power, I know of no better means of relief, and no better

prophylactic when the attack has passed off, than that afforded by the use of the cold sponging-bath and friction of the skin. It is not every constitution, however, that is capable of bearing this somewhat severe method of rendering the skin an active organ, and care is therefore requisite in prescribing such discipline. Whatever the condition of the patient, however, as regards diathesis or constitution, we shall seldom do wrong in enjoining the daily use of the horse-hair gloves or flesh-brush, applied over the surface every morning. Steady exercise, always short of fatigue, is an important adjuvant in every form of lithic disease in its early stages. The increased exhalation thus obtained from the skin, of those nitrogenous ingredients of the blood which are constantly excreting from the nephritic and cutaneous surfaces, will be found greatly to relieve the kidney, and produce urine less abounding in lithic acid.

The general treatment of the sediments composed of lithates nearly corresponds with that required for the relief of the lithic acid form of deposit; viz. tonics and alteratives, with the use of cutaneous friction.

In persons who become the subjects of this deposit after excessive exertion or occasional irregularities of diet, the free use of cold bathing and frictions in the morning, as a habit, will constantly be found a most rapid means of effecting a cure.\* It would appear that weakly persons, in whom the cutaneous surface is inactive, convert the tissue wasted during exertion into a constituent of the urine, rather than into an excretion of the skin, and thus it is that, after exercise, some persons become liable to the deposit of lithates. The improvement of the general health by acid tonics and shower-baths is in such cases attended with immediate relief from urinary symptoms.

It is not uncommon to find patients in whom, for days together, an alternation takes place by the excretion of phosphatic deposits on the same day with the lithate of ammonia—the one forming the deposit of the night urine, the other

\* So complete is the influence of cutaneous friction on the urine of these cases, that I have known its omission followed by an immediate return of the deposit, which again disappeared on having recourse to the sponging-bath.

that of the morning. This form of urinary affection is often observed in persons of advanced age, and is then generally attended with considerable irritation, and frequently complicated with disease of the bladder, prostate, and urinary passages. The phosphatic deposit is generally composed of the monobasic ammoniaco-magnesian salt, and the lithates are of the nut-brown colour. In some cases the explanation of this condition would appear to consist in the fact, that during the day the skin is less actively engaged in excreting water than during the hours passed in bed, and that therefore more water appears with the evening urine, and thus the deposit of lithates is prevented, while the irritable mucous membrane of the urinary passages pours out an alkaline secretion in a sufficiently large quantity partially to neutralize the acid of the urine, and thus lead to a condition favourable to the crystallisation of the phosphatic salt. During the day there will, of course, be causes of irritation in action on the mucous membrane which do not exist during the night, and we therefore have the alkaline flux from that surface occurring in increased quantity in the day-time. When this alternation of phosphates with lithates occurs in the urine of young persons, it is indicative of the phosphatic tendency, and generally co-exists with irritation of the gastric as well as urinary mucous membrane.

In severe dyspeptic cases characterised by the deposition of the lithates either of a lighter colour than usual or of a red tint, we sometimes observe, as mentioned before, that sugar can be detected in small quantity. The patient himself will sometimes mention that he has observed a peculiar odour in his urine. These cases should be treated with the greatest care, and the patient fully informed of the danger to which he will subject himself by neglecting the rules of life and method of treatment enjoined by the medical adviser. In the general, we shall seldom do wrong to prescribe small doses of opium in these cases, in combination with ipecacuanha, at night, while the greatest possible benefit will be derived from the use of the hydrochloric acid in large dose. I have lately been induced, from the benefit derived from the use of this remedy, to make trial of its efficacy in confirmed diabetes, but have not yet had suffi-

cient experience to speak confidently of its powers. Strict attention to the bowels and state of the liver, as shown by the stools, is very necessary in the treatment of this class of disease, which is frequently connected with visceral obstruction.

The pink deposit of lithates is so generally connected with rheumatic or gouty disease, or with organic visceral mischief, that the treatment necessary must vary with the peculiar character of each case, and the indications of the urine in no way allowed especially to influence us, either in the adaptation of means, or the selection of remedies.



## ON THE PHOSPHATIC DEPOSITS.

THESE deposits generally occur in urine possessing a specific gravity lower than that of health; sometimes it is found slightly acid, but generally neutral or alkaline. When viewed under the microscope, these deposits assume peculiar definite forms, indicating their character. (Vide description of plate, figs. 1. and 2.) Examined chemically, they yield the re-actions described at p. 51.

The forms of disease characterised by the deposit of the bibasic stellated salt of ammonia and magnesia do not always necessarily differ from those yielding the monobasic salt, the deposit showing itself either as one or the other, according as more or less alkali is developed in the urine. The stellated bibasic salt is, however, as a general rule, observed in the more advanced cases yielding alkaline urine, and is constantly present in the latter stages. The decomposition of urine containing the monobasic salt, owing to the generation of ammonia, frequently causes a deposit of the stellated crystals to occur in combination with phosphate of lime. This is far from uncommon when, from long-continued exercise or a full meal, the patient passes urine of high specific gravity, that is to say, from 1028 to 1031, or even higher than this.

We may divide the cases of alkaline urine into two classes; 1st, those depositing the crystalline sediment, and, 2dly, those depositing the amorphous white sediment. The first of these is the most frequently met with in young persons, while the last is generally indicative of confirmed mischief, and observed most frequently in old age in connection with disease of the bladder and prostate; it is also a sequela of calculous disease in every form, at the advanced period of life.

Dr. Prout, in treating of these affections, has described a variety of disease as separable from the two above mentioned, and as characterised by the secretion of the carbonates of soda, potash, and ammonia. From the descrip-

tion of this variety of urine, and the symptoms accompanying its excretion, it would seem to be produced as the result of that state of the urinary apparatus occurring in advanced stages of prostatic disease, when the ureters and kidneys have become involved, owing to the continuance of obstruction by stricture. Thus in cases going on to suppurative disease of the kidney, the urine is voided of this character, which I believe to be entirely dependent on the state of the canals from the kidney to the urethra acting on the urine after secretion, rendering it ammoniacal and mixed with blood, and in no way to be connected with any peculiar constitutional condition influencing the secretion of the kidney. As regards the question of phosphatic deposits generally, and the tendency to the alkaline character of the urine, I feel persuaded that in nearly all cases the real disease exists, not in the presence of any peculiarity on the part of the kidney as a secreting organ, but on a tendency to the production of alkaline fluid on the lining membrane of the whole, or a part, of the urinary apparatus. The treatment of these diseases, as founded on this view of their pathology, has led to such favourable results, that I am daily becoming more and more persuaded of the truth of the position. It has been far too much the fashion to regard the abnormal qualities of the urine as indicative of some general state of the system showing itself through the medium of the kidney, whereas it almost admits of demonstration that the kidney frequently secretes urine possessing the qualities of health, with its acid re-action and other normal qualities, while it passes from the urethra fœtid and ammoniacal. I do not here allude to cases of old bladder disease, or on that condition of the viscus observed in cases of spinal lesion, but to cases admitting of cure, and not necessarily characterised by any symptoms of cystitis. A young or middle-aged person becomes the subject of irritation during the passage of urine, in connection with gastric symptoms, and aching irregular pains in the course of the ureters. His appearance is that which we are apt to describe as indicative of a general want of tone, and on examining his urine we find it either ammoniacal, neutral, or faintly acid, with a deposit of mucus and phosphates. If it be supposed that this depends on mal-secretion on the

part of the kidney, knowing as we do that mineral acids will increase the acidity of healthy urine, nothing can be more reasonable than to supply these remedies for the cure of the patient; but if, on the contrary, no such mal-secretion is going on, and the urine only becomes alkaline after leaving the kidneys, and during its course through the passages, nothing can be required from the mineral acids. That, however, which remains to be done, in accordance with the pathological view I have advanced, is to act upon the urine in such a manner as to render it less irritating to the lining mucous membranes, and thus prevent the secretion of that alkaline flux which has been pouring out in quantity. It appeared to me that the use of alkaline remedies might be of advantage in these cases of alkaline urine, and, moreover, that if the alkali were administered in small doses so as only partially to neutralise the acid state of urine as secreted by the kidney, we might relieve the irritation of the mucous membranes, stop the excretion of alkaline matter, and have an acid urine excreted, the natural acidity having been only partially destroyed by our remedy. It may appear somewhat unaccountable to those who merely look to the chemical view of the matter that any one should expect to render alkaline urine acid by the administration of alkalies, but such was the treatment I adopted, and the result fully corroborated the correctness of the theory which suggested it as a crucial test.

The first case I met with, and which afforded the symptoms indicative of phosphatic disease, occurred in a gentleman of leuco-phlegmatic temperament, who had suffered much from despondency, and whose urine was generally alkaline and occasionally neutral. His appetite had given way; his bowels were constipated; and he had become the subject of shooting pains in the loins and down the ureters. There was no very great distress experienced in passing urine, nor was there frequent desire to do so at any period of night or day. The excretion was loaded with mucus mixed with the earthy phosphates.

In this case I exhibited the liquor potassæ in doses of twenty minims three times during the day, combined with hyoscyamus, in a mucilaginous vehicle. The result was, that my patient's urine became acid on the second day, and

continued so till all his disagreeable urinary symptoms were removed. It was not of course necessary to continue the alkali beyond this point, as by its prolonged use it undoubtedly would have eventually caused an alkaline urine to be secreted from the kidney. At this period of treatment, therefore, I had recourse to tonics containing an acid, a form of medicine which had been tried before the alkali was exhibited, and had produced so much irritation and so great an increase of the fœtid odour of the urine without decreasing the deposit, that we were forced to abandon its use. It was found, however, that the acid could now be borne with advantage, and much good was obtained by its careful exhibition.

The second case in which I had an opportunity of making the same kind of observation occurred among the patients at Guy's Hospital, in the person of a woman under the care of my friend and colleague, Dr. Babington, who kindly allowed me to prescribe for his case.

This patient had been subject to fits from childhood, and was admitted into the Hospital for the cure of epilepsy. She, however, became suddenly seized with urinary symptoms, experiencing difficulty in passing her urine, which was turbid, alkaline, and fœtid if long retained. When I saw her she was stated to have suffered increased distress from the exhibition of acids, though there were no indications of bladder disease. The quantity of mucus voided was very considerable; the sequel of this case, however, as well as its history, sufficiently showed that the bladder was not materially involved. The acid remedies being laid aside, I ordered this person the liquor potassæ with tincture of hyoscyamus three times a day, and in a few days had the satisfaction of perceiving the urine passed to be of acid re-action, clear, and in every respect natural.

I am not prepared to say that all cases characterised by the deposit of the earthy phosphates are pathologically identical with those alluded to above; but I am certain that in the greater number of cases in which alkaline and neutral urine exists, with mucus and phosphates as a deposit, we shall find alkaline remedies of avail; and that if given in regulated dose we shall by their action obtain the excretion of an acid urine, showing that the cause of mis-

chief is seated below the kidneys, but not necessarily in the bladder.

In the mild form of disease in which we observe the triple phosphate as an occasional deposit, we shall often detect a general state of irritability, with gastric disturbance, which I believe is connected with a condition of the urinary mucous membrane resembling that so evidently produced upon the gastric surface, as shown by the tongue and state of the bowels.

I am satisfied the urine is not secreted in an alkaline state in many of these cases, but that the deposits of phosphates occur occasionally in consequence of an alkaline discharge taking place from the mucous lining of the kidneys and ureters, just in the same manner as we know the mucous intestinal surface to be irregular in this respect, subjecting the patient one week to constipation and the next to diarrhœa, of a mixed mucous and bilious character.

Now, an alkaline state of the urine will account for the deposit of the phosphates contained in it; but it can in no way be regarded as a cause for their absolute increase in proportion, and when this takes place, very important changes must be going on in the economy. In mollities ossium this increase occurs, and probably in other forms of disease; but the great multitude of cases met with in practice are not of this kind, but are rather to be considered as instances in which no increase takes place in the positive proportion of the phosphates, but which, owing to the urine becoming alkaline or neutral, are characterised by the deposit of those earthy salts which were before held in solution.

Any one in health may assure himself that the normal proportion of earthy phosphates is sufficient to produce a copious deposit, by adding ammonia to his urine, and allowing the precipitate to subside. If it be remembered, when making this experiment, that an excretion of mucus frequently accompanies the deposit of phosphates, greatly increasing its apparent bulk, it will probably be a matter of surprise to the experimenter, that the phosphatic deposits occurring in disease are not even more voluminous than they are observed to be. The mucous membrane of the bladder has been supposed to secrete phosphate of lime in considerable quantity, and many circumstances connected



with the history of calculous disorders would tend to support such an opinion. With the knowledge, however, of the capability of the mucous surfaces to secrete an alkaline mucus, and the facility afforded for the deposit of phosphatic salts from the urine in virtue of this property, great care is required before such an opinion can be generally adopted in the case of the urinary organs. There is an apparent analogy afforded here by the intestinal mucous surface, which is known not unfrequently to produce calculous matter, but these masses are of slow growth, and it is not easy to determine how much may depend upon the decomposition of the chylous and other fluids containing phosphates, by detention in the neighborhood of diseased portions of membrane. A reason which has been quoted for conceiving the concretions in both cases to depend on the secretion of earthy matter by the membrane itself, is, that a deficiency of the magnesian salt is observed in the urinary concretion, which could scarcely be expected were it derived from the urine, simply owing to the production of alkali by the membrane. These concretions, however, really contain magnesia in considerable quantity.

Carbonate of lime is sometimes found associated with phosphate adhering to the surface of mucus voided from the diseased membrane of the bladder in advanced cases, which may possibly be the result of decomposition of the urine, but the mucous membrane can scarcely be supposed to secrete a carbonate. On the whole, the probability is greatly in favour of such deposits being dependent on the decomposition of the fluids passing over the membranes, rather than on any power on the part of the surfaces themselves to secrete earthy salts.

There is a condition of urine to which I have directed attention in a former part of this work, in which we find that it deposits a precipitate of the earthy phosphates on the application of heat. This state of urine has been described as dependent on the presence of an excess of the earthy salts, whereas it is rather the result of a tendency on the part of the constituents of the urine to arrange themselves in a peculiar manner; the phosphates thus depositing not necessarily indicating their presence in excess. The urine may be acid or alkaline, and yet this deposit occur; in the former case,



however, the deposit generally consists of the triple phosphate. On considering generally the pathology of the phosphatic deposits and the tendency to the secretion of alkaline urine, which is an almost constant concomitant, it would appear that the general system, so far as is shown by the secretion of the kidney is rarely so seriously involved as has been supposed; that, in fact, the mucous surfaces are involved rather than the nervous structures, which has been assumed as a condition necessary to the existence of this class of affection. The facts, we observe, in the great majority of cases are easily explained on the former supposition, while, if we except some cases of paraplegia, little else than gratuitous assumption has been brought forward in support of the latter opinion.

In the management of these cases, it is of the utmost importance to watch the urine as an index of the effect of the remedies employed, and when about to commence treatment, much is to be done by examining the excretion several times before any plan is determined upon. If the general symptoms observed are those of gastric irritation, and the urine deposits mucus with either an amorphous or crystalline phosphatic sediment, we may conclude that alkaline remedies are indicated as the first part of the treatment, and that the kidney is not greatly in fault. The bicarbonates may be exhibited with advantage in such cases. If, on the contrary, we observe a large amorphous deposit in conjunction with blood and mucus, while the urine is extremely foetid, and incontinence exists as a symptom, we may conclude that fatal disease is established, and the kidney in all probability is greatly involved in the mischief. Little remains to be done in such cases than to palliate the sufferings of the patient by attention to diet and regimen, while care is taken that any stricture existing is prevented exercising a pernicious influence by the constant use of the catheter. In the former class of cases, the use of alkalies should be discontinued immediately we perceive the urine to have become acid under their employment, and then alteratives, containing mild mercurials and ipecacuanha, with vegetable tonics, will generally complete the cure. It will be found in some few cases of recent origin, and of mild character, that the use of alkalies may be dispensed

with, and this is especially the case when the morobasic triple phosphate alone is secreted; but if any considerable irritation be observed, and mucus detected in abnormal proportion in the urine, it is always well to combine an alkali with our tonic remedy. As regards diet in this form of disease, we can say little more than enjoin general temperance and the use of nutritious and easily digestible food, while all articles of diet either solid or fluid, known by experience to produce flatulency, should be carefully avoided.

I shall now say a few words on the treatment of that form of phosphatic disease so often set up during the formation of a calculus, and which, as the result of irritation of the mucous membrane of the bladder, is complicated with certain peculiar conditions of the urine. A knowledge of these conditions is absolutely necessary before we can form a correct prognosis, and the determination of the value of signs observed must often influence the conduct of the surgeon in attempting the permanent cure of his patient by operation. Whatever may be the nature of the original deposit forming a calculus in the bladder, it constantly happens in irritable subjects that the urine becomes alkaline, while mucus and phosphates occur as a deposit. The bladder next becomes further affected, and pus is poured out in addition to the mucus and phosphates; while owing to the excretion of this pus from the lining membrane of the bladder, albumen may be detected dissolved in the urine. Now, an albuminous state of urine occurring independently of the presence of pus or blood, and showing itself day after day, is an indication of disease of the kidney, and if such disease could be discovered to exist, our prognosis would be very unfavourable; but if, on the contrary, we are able to trace the presence of the albumen dissolved in the urine to the existence of pus, our prognosis assumes a more favourable character, and hopes may be reasonably entertained that on the extraction of the calculus the bladder will be relieved from irritation, and the urine assume its healthy qualities. Under these circumstances it becomes of extreme importance to determine the absence of kidney disease; and we shall rarely fail to do so by attention to the following rule:—If the bladder alone be in fault, we shall always find that the quantity of albumen to be detected in the urine by

the nitric acid test will bear a proportion to the quantity of purulent deposit, and the urine must be examined from day to day in order to determine this point. If, on the contrary, the albumen to be detected does not undergo diminution or increase in quantity proportionally with the purulent deposit, we may reasonably suspect the kidney to be involved. A case of calculus in the bladder lately occurred at Guy's Hospital, under the care of my colleague, Mr. Morgan, in which I was consulted, in consequence of the existence of albumen in the urine rendering the propriety of operating a matter of doubt. In this case pus, mucus, and phosphates were passed from the bladder; and by repeated observation I assured myself that on favourable days, when but little pus appeared, a corresponding decrease took place in the proportion of albumen in the urine.

I therefore had no hesitation in expressing an opinion that the operation would benefit the patient, by relieving the bladder of that cause of irritation on which the presence of albumen in the urine depended, and that in all probability the kidneys were unaffected. This patient underwent the operation, and recovered rapidly, his urine, after the healing of the wound, being no longer albuminous, which would not have been the case had he been affected with kidney disease.

When relief from calculus symptoms cannot be obtained by operation, and phosphatic deposits become mechanically inconvenient, we shall generally find that the benefit which might at first view be hoped for from the solvent action of acid remedies cannot be obtained, inasmuch as the urinary mucous membrane only becomes the more irritated by their use, and the urine more loaded with mucus and phosphates. In such cases, alkalies in small dose are frequently of service, and much advantage has occasionally been gained by the dexterous use, on the part of the surgeon, of sedative injections made weakly acidulous by nitric acid.

## ON THE OXALATE OF LIME DEPOSITS.

URINE depositing the oxalate of lime often possesses a peculiar greenish-yellow colour. It is seldom of a specific gravity, varying greatly from that of health. Viewed under the microscope the deposit represents forms shown on the plate (fig. 9.) When examined chemically it yields the re-actions described at page 59. These crystalline forms would appear, according to the statements of Dr. Bird, to be of more common occurrence than was formerly supposed the case.

The state of system on which the secretion of urine characterised by the deposit of oxalate of lime depends is not well investigated. There appears some degree of probability that it is connected with the formation of lithic acid in excess, and with that state of system in which a considerable portion of urea is secreted. This view has been advocated by Dr. Willis, and since adopted by others. Dr. Prout, however, states that he has known several instances in which the abuse of sugar led to the oxalic acid form of dyspepsia, and afterwards to the formation of calculus.

The pathological chemistry of the subject is at present somewhat a matter of doubt, and it would almost appear that more than one source existed for the production of a tendency to this form of disease. Further and more correct observations are needed into the physical condition of patients suffering from oxalate of lime deposit than any we yet possess. We find that chemistry is at no loss, however, to devise theories for the transformation of several organic principles into oxalic acid, and whether it be derived from sugar, urea, or lithic acid, we can make our formulæ by abstracting or adding oxygen as the case may require. All this, however, must be looked upon as a display of ingenuity on the part of the chemist, and we should wait till accurate and long-continued observation, conducted on the urine of patients, helps us to better evidence on which to found a conclusion. Unfortunately, the addition or sub-

traction of oxygen necessary to some of these theories has not been proved or even rendered probable, and no good reason has been given in most cases for transforming one proximate element rather than another for the formation of a diseased product. It is often the case that more than one proximate element would answer the purpose required, owing to their similarity of composition ; and the profusion with which chemists are in the habit of taking away or adding oxygen by as many atoms as may please them, still further lessens any difficulty that might at first appear to stand in the way of effecting an explanation.

In connection, however, with the subject of oxalic acid, as produced in the urine, I have great pleasure in noticing a contribution to the pathology of oxalia disease by Dr. Aldridge of Dublin\*, who so far differs from most other chemical theorists of the day that he has really rendered it more probable that oxalic acid is formed from lithic acid than from any other of the constituents of the urine. This gentleman has shown that lithic acid, by the addition of the elements of water, in varying proportion, may theoretically be converted into oxalate and carbonate of ammonia, hydrocyanic and formic acids, according to the circumstances of decomposition, and further, by heating urine, and in some cases evaporating it, has succeeded in producing reactions in the fluid indicative of the presence of the acids above named ; oxalate of lime depositing, while evidence of the hydrocyanic and formic acids could be obtained from the fluid. This is really a step in pathology, and has more practical bearings than may at first sight appear evident. Now when urine is secreted by the healthy organism, we know that the constituents are so arranged, that the fluid possesses certain definite qualities recognised as those indicative of health, and that when disease sets in, there is sometimes observed a tendency on the part of the constituent elements of the fluid to arrange themselves in a different manner to this, and that, too, without any very notable increase or decrease in the proportion of such elements being observed. Considering the question in this point of view, and remembering that in Dr. Aldridge's experiments no re-agents were had

\* See Bird on Urinary Deposits, p. 160.



recourse to, and that ebullition alone produced oxalate of lime in healthy urine, which did not yield such crystals before being boiled, we are justified in the belief that such a deposit may very easily form in the urine in certain states of system after secretion by the kidneys, and during its detention in the urinary tubes and bladder. It seems highly probable that in some cases which have been described, the oxalate of lime has been rather formed after the urine has been secreted, than as a result of the secreting process; and Dr. Aldridge's experiments point to the absolute necessity of examining urine soon after excretion, and without applying heat, which tends to the formation of oxalate of lime even in healthy urine.

The symptoms observed in those who suffer from the oxalate of lime deposit are characteristic of general debility and irritation, not unlike those observed in the phosphatic form of disease; with the exception, that the patient is liable to the more severe forms of hypochondriasis, and frequently to such an extent as to cause considerable anxiety on this account alone. This tendency to extreme depression indeed would seem to form a distinctive character of the complaint. The uneasiness experienced after taking food, so commonly felt in dyspepsia, is, in this disease, very frequently accompanied with disturbance of the circulatory system, attended with palpitation and dyspnœa. The bowels are often constipated while the tongue is coated and white.

In advanced cases, however, we sometimes observe the tongue to be dry, clean, and glazed. When oxalate of lime calculi are forming we frequently observe a tendency to hæmorrhage from the kidney, which accounts for the peculiar colour observed in this variety of concretion.

In advanced cases of this disease Dr. Prout describes a peculiar tint of complexion, of which, however, I have never been able to satisfy myself, though I lately observed very much what he has described in a patient suffering from calculous symptoms, whose urine, unfortunately, I had not an opportunity of examining, but whose history was by no means discordant with the existence of oxalate of lime in the urine.

The treatment of this form of disease in the early stage is such as is applicable to all forms of dyspepsia. It is often



combined with symptoms of irritation and mental anxiety, which demand the use of sedatives in combination with alteratives; but it is advisable, as much as possible, to avoid the use of the former. I have no doubt that much mischief has arisen from the indiscriminate use of sedatives for the cure of this disease, and that attention to diet, with the enforcement of regular exercise, especially in the evening shortly before retiring to rest, would have answered every purpose, without enfeebling the system as by the use of hyoscyamus, conium, and such class of remedies. A fish diet is of the greatest service in this affection, nor is there any objection to the use of vegetables in moderation. Wine is very generally preferable to beer, which can seldom be taken by the patient without giving rise to distressing flatulency. In severe cases the use of frictions to the skin is advisable every morning, with the warm bath at intervals of three days; but in slighter cases cold bathing and friction is of far more service, and will be found to assist and expedite the cure in every case, as recovery advances. As regards the use of medicine, there is no doubt that in effecting the removal of the oxalate of lime deposit great benefit is frequently derived by following Dr. Prout's suggestion of prescribing acids; but perhaps the most important secret, in mild cases, consists in emptying the intestinal canal, which will sometimes be found sufficient to remove the whole mischief. Attention to this point, combined with the administration of alteratives, and acid tonics, comprises nearly all that need be done in the general treatment of oxalate of lime deposit. The severer form of this affection is to be classed among the most obstinate of urinary diseases, and being liable to return upon the least exposure or intemperance, the patient often becomes a prey to the most complete despondency. In such cases calculi frequently form, and the phosphatic salts appear in the urine, which loses its acid re-action, while the state of the patient deters the surgeon from removing, by an operation, that which has now become an additional source of misery. In this form of urine, the exhibition of alkaline remedies is of the greatest service. The liquor potassæ or bicarbonate of potash, in moderate dose, combined with hyoscyamus and mucilage, are to be preferred, while, if there be much irri-

tation during the night, with frequent micturition, an opium suppository should be introduced, followed in the morning by a saline purgative.

There is an anæmiated condition in these patients, which is greatly benefited by the administration of iron and salines; and when the more urgent symptoms can be subdued, it is always right to have recourse to such a plan of treatment.

## CYSTINE, ETC.

The cases in which cystine has been detected as a constituent of the urine have been so few that sufficient opportunity has not yet been afforded of investigating the pathology of the subject, and ascertaining the principles which should guide us in treatment. I shall not, therefore, enter here upon a description of the disease; and for the same reason, while considering treatment, refrain from noticing the subjects of xanthine and the fibrinous calculus.

## ON ALBUMINURIA, OR THE MORBUS BRIGHTII.

THIS disease has now been a matter of observation and experiment to the profession for many years, but unfortunately so far as treatment is concerned, little advance has been made since the discovery of Dr. Bright was first announced to the public; and it is curious to reflect upon the fact, that, while in its milder or more recent forms it occasionally yields to the simplest remedies, yet in a somewhat more advanced stage every variety of means adopted for its cure has either failed or met with but partial success. We can, however, I believe in the present day, do more to lengthen life, and render it supportable by the application of remedies in the advanced stages than was formerly the case; and our inability to perform cures must rather be attributed to the nature of the affection than the want of perspicacity on the part of the profession.

The researches of Dr. Bright, which pointed out the connection between this albuminous state of the urine and granular disease of the kidney, first attracted attention in connection with the subject of anasarca; but the further observations and publications of that discoverer subsequently made us acquainted with other and more general states of system of the highest importance to pathology, as connected with the excretion of albumen with the urine. We may now, indeed, regard the state of kidney as associated with albuminous urine as indicative of a state of the fluids generally, tending to modify and complicate nearly every disease to which the patient may become liable, either from exposure or accident. Not only do we occasionally observe kidney disease and albuminuria, when no indications of anasarca can be detected in the patient, but I have known some of the most fatal cases of apoplectic seizure to occur in those who exhibited scarcely any signs of œdema, showing that anasarca must be regarded only as an occasional and not necessary symptom of some general morbid derangement. Why the kidney should be more prone to

congestion or granular deposit than any other organ cannot be explained in the present state of our knowledge; but if we assume the blood as first implicated in the disease, this would seem a necessary step to prove, as all the other organs are supplied with the same blood. This is a difficulty; and yet that the kidney is originally involved scarcely seems consistent either with physiology or the history of the complaint. Thus, in the mild forms admitting of cure, we very often observe extreme degeneration of the blood, and the urine loaded with albumen, and yet in such instances the kidney can be but slightly diseased, for permanent recovery often takes place. The albuminous urine appears, therefore, in such cases to be connected rather with a degeneration of the fluids than a disease of the kidney, since that organ is almost certainly in merely a congested condition. The researches in morbid anatomy which have been pursued in connection with this subject seem clearly to point to the kidney as the first link in the chain of causation so far as the solids are concerned; and the lesions of heart and liver so often remarked in cases of albuminuria hold comparatively an unimportant place in the pathology of the affection. The changes effected in the kidney during the early stage have been noticed principally in acute cases, rapidly fatal from the supervention of some disease complicating an important organ. In such patients the kidney has shown extreme congestion, the cortical portion especially being distended, and appearing as though the cellular structure of the organ had become filled with extravasated blood, giving it a dark, chocolate-brown colour. The next change observed in the kidney in the course of this disease may be regarded as that indicative of the commencement of grave mischief, and threatening permanent alteration of the structure of the organ. The cortical portion now becomes impregnated with an albuminous deposit, encroaching gradually at parts upon the tubular structure. At this stage the organ frequently varies from its natural size, becoming larger and softer, or smaller and harder; its colour also changes to a more yellow tinge, and white markings and dots appear on its surface, giving an appearance of mottling, which at once strikes the eye on tearing off the investing membrane. In the latter stages of

degeneration the kidneys become one mass of disease ; the tubular as well as cortical portion has become compressed by the morbid deposit ; absorption of their natural structure seems to have taken place, and they are generally found compressed and hardened. When cut through, the natural structure seems to have become obliterated ; and the whole organs appear made up of a white albuminous matter, representing imperfectly, in some places, an approach to tubular arrangement. The kidney is now generally observed to present an irregular surface, the protuberances varying in size from mere papillary elevations to large rounded prominences, which give a lobulated form to the organ. When the investing membrane is torn off, we see the kidney of a light colour, with occasional dark spots or ecchymoses in streaks variegating its surface.

The above are the principal appearances put on by the kidney, as the granular disease advances, and in every stage we observe the urine to contain albumen. The first question which might be expected from the pathologist who was for the first time made acquainted with the fact that this degeneration of the kidney was accompanied with the excretion of albumen by the kidney, would be an inquiry as to whether the proportion of this principle found in the urine bore any relation whatever to the stage of degeneration to which the kidney had advanced. This relation, however, is wanting ; and we yet need a guide for determining, in many cases at least, at what stage the disease may have arrived when examining our patient.

The proportion of albumen excreted is generally observed most abundant in early stages of this affection, and is sometimes scanty in very advanced cases ; the reverse of this, however, is sometimes the case in these latter instances. In early cases the specific gravity of the urine is often but little changed from that of health ; but I have occasionally seen it as light as 1010 and 1012—a specific gravity which rather belongs to the latter periods of the disease. In the early stages the quantity of urine excreted is very variable, being sometimes much less than the healthy proportion, and at others equalling that amount. This, together with the fact that the specific gravity of health is sometimes maintained, might lead to the supposition that the evacuation

of solids by the kidneys was going on to a natural extent ; but Dr. Christison has shown that the preservation of the normal specific gravity is owing to the presence of albumen ; and that if we separate this principle we shall find evidence, from the decrease in the weight of the urine, that the daily discharge of the normal solid matters by the kidney is much less than that occurring in health. In the advanced stages of the disease the quantity of urine passed during the day is very variable ; it occasionally possesses a very low specific gravity, generally from 1010 to 1015, and the proportion of urea is greatly diminished. In one specimen I examined no trace of lithic acid could be detected.\* When a large proportion is passed, this low specific gravity always pertains ; but sometimes when the skin has been active (a common occurrence in advanced cases,) the specific gravity of the urine will rise nearly to the normal standard, a proportional decrease occurring in the quantity excreted. In the later as well as early stages of this affection, the solid matter evacuated with the urine during the day is far below the proportion of health.

When testing urine for albumen, we should never be contented with a single examination, as it has been observed free from albumen on some days, even in confirmed cases.

The state of the blood in advanced stages of this disease is such as to render it unfit for the discharge of those functions necessary to the preservation of life, and it early becomes materially degenerated. The three conditions most prominently shown by analysis are the deficient proportions of albumen and hæmotosine, according to the stage of the disease, and the existence of urea in the blood, probably in conjunction with other principles found only in the urine in the healthy state of the system. This contamination of the blood by urea occurs in various other affections, and appears common to every condition of body characterised by ischuria to any extent.

Immediately that albumen commences passing from the kidney the blood begins to degenerate. The proportion of albumen becomes less, and the specific gravity of the li-

\* It has been considered as probable that in the course of this disease the lithic acid or lithates may alternate with albumen in the urine. Vide Med. Gaz. April 9, 1836.



quor sanguinis diminishes. As the disease advances, the proportion of blood corpuscles is observed to decrease, while not uncommonly the albumen approaches to its healthy proportion. The quantity of fibrin varies greatly, being generally, however, somewhat above the natural proportion, and becoming increased if any inflammatory action takes place in the course of the disease. Dr. Christison states that he has observed the albumen in the serum of some advanced cases to be above the healthy proportion. I have never yet observed this; but more than once have known it approach the proportion of health. The highest specific gravity of serum observed by Dr. C. was 1031 in the advanced stage, and 1019 is mentioned by him as the lowest in the early stage. In the latter case, however, I once saw serum as low as 1015.\*

Having now given a general sketch of the changes observed in the kidney and the degenerations of the blood and urine characteristic of this disease, I proceed to consider the causes and symptoms; premising, that there is a difference observed in its duration and severity which appears to authorise a division into the acute and chronic forms.

When albuminuria sets in it is often to be traced to exposure to cold, or a damp and cold atmosphere, under circumstances of depression and fatigue, sometimes, also, to intemperance, and, more especially, the use of ardent spirits. The type this disease may assume, as regards the acute and chronic forms, would appear to depend on the age, constitution, and habits of life of the patient. Thus in some we find such exposure followed by immediate and violent re-action, indicated by a hot skin and dry tongue, with a hard pulse, pain in the head, and severe thirst, while pain in the loins, and sometimes, but not always, ischuria, point to the kidney as the seat of mischief. The urine is high coloured, loaded with albumen, and occasionally tinged with blood. The stomach is irritable, and vomiting not unfrequently occurs, while partial œdema of the face, or complete anasarca, are the most common concomitants.

\* For physico-chemical experiments on the causes of deterioration of the blood in the Morbus Brightii, vide Guy's Hospital Reports, April, 1843.

There is great liability to complication by serous inflammation in this form of the disease ; and it is thus, in fatal cases, that life is most frequently destroyed. All symptoms which may be referred to the brain are to be carefully watched ; as coma and epileptico-apoplectic seizures will sometimes suddenly prove fatal.\* When by the early application of remedies this acute form of albuminuria is relieved, it appears probable that complete and permanent cure is sometimes effected ; but, again, in a large number of cases there is little doubt that such acute attack is followed, at no very distant interval, by the same set of symptoms assuming a more chronic type ; and that by repetitions of these attacks the patient sooner or later sinks.

Mild cases of short duration, and generally admitting of permanent relief, are often observed after scarlatina in children, occasioning the anasarca so common as a sequel to that disease.

As regards the chronic form of albuminuria, though we often find on interrogating our patients that they have before suffered from anasarca and other symptoms indicative of the previous occurrence of the acute disease, we as often meet with chronic symptoms as the first indicated by the patient ; and these not unfrequently supervene in so masked a manner, and encroach so gradually on the comfort of the individual, that a practised eye is necessary to detect the disease by the slight indications now afforded, and which, when the condition of the urine has been overlooked, have often passed for those of dyspepsia or inactivity of the liver. As regards the symptoms in this chronic form of the affection (though nearly identical in kind,) we have them present in a less marked degree than when characteristic of the acute disease. The pain in the loins is much less severe, and sometimes absent. Ischuria, as in the acute form, is not necessarily a symptom, and more commonly, as stated before, large quantities of urine are voided ; from 70 to 100 ounces per diem being no uncommon discharge. Anasarca is frequently wanting as a symptom, or only indicated by slight œdema of the face ;

\* See Guy's Hospital Reports, No. 8. Dr. Addison on Disorders of the Brain connected with Disease of the Kidneys.

thus the under eyelids are occasionally swelled, and that only in the morning, and sometimes so slightly, that the patient does not observe it. Dyspeptic ailments, with irritability of stomach, are often present; and when complained of as producing vomiting, may serve to guide us to the examination of the urine, and consequent detection of the true nature of the patient's disease. In this chronic form of the complaint it is often observed that the urine becomes a source of irritation to the bladder, and the patient is distressed with frequent desire to make water, leaving his bed several times in the night for that purpose. This condition is not necessarily connected with a discharge of lithates or lithic acid, which are the common deposits in albuminuria, nor with any peculiarity of the excretion as yet ascertained.

There are many complications attendant on this disease of the kidneys, dependent, in all probability, on the state of the blood, though we are at present unable to trace the manner in which it influences the solids, and much remains for experiment and observation. It may be well to remark, however, in connection with this subject, that the deficient proportion of albumen and hæmotosine, the one observed in the early and the other in the later stages of the disease, are as prominently marked in certain cases of leucorrhœa going on to chlorotic anæmia, as in the disease of which we are now treating; and that I have had occasion to prove the presence of urea in the blood, and that too in considerable quantity, in a case of the mild form of albuminuria occurring after scarlatina, and which was rapidly cured. These facts would seem to show that the state of the blood in albuminuria requires further experiment. The organs most commonly implicated in albuminuria, in addition to the kidneys are the heart, the liver, and the brain; and in examining cases it is of great importance to ascertain their conditions, so far as we are able, by physical signs, as well as by the evidence to be obtained from symptoms described by the patient. The state of the brain especially should be watched, as death is commonly occasioned by implication of that organ. In many cases, however, œdema of the glottis with more or less bronchitis, or sudden effusion into the pericardium, closes the disease.

The treatment of acute albuminuria differs materially from that adapted to the relief of the chronic form of the disease; and we frequently find that the simplest means are capable of working a permanent and rapid cure. This is remarkably the case in those instances of albuminuria and anasarca observed after scarlatina, in which mild purgatives and salines are generally found sufficient remedies. In other cases, however, the acute form of this disease is attended with violent symptoms requiring the active interference of treatment for the preservation of life; and this remark applies to some few cases of anasarca occurring after scarlatina, though these, for the most part, are mild in character.

When acute albuminuria exists, I have always found the greatest benefit from treating the disease by the application of remedies affecting the skin. Of the various plans of treatment recommended, nearly all of which I have either seen practised or myself prescribed, I must confess that none ever impressed me so fully with a conviction of its beneficial effect as that which enforced the use of diaphoretic remedies as a principal means of obtaining relief. The favourable results which have been observed from the use of antimony I feel no hesitation in ascribing purely to its diaphoretic action, and further than this, am inclined to prefer, in most cases, the use of ipecacuanha, or of Dover's powder: the latter a formula in which the opium present assists us greatly in obtaining a ready action on the skin. The use of the warm bath every other day, with acetate of ammonia and Dover's powder, taken in draught twice during the twenty-four hours, if combined with the occasional administration of saline purgatives, will generally be found an excellent plan of affording relief in acute cases, unattended with any inflammatory complications.

When, however, bronchitis or pneumonia are discovered to exist, we should have recourse to depletion with mercurials, but may still continue our diaphoretics as a part of the treatment. As regards depletion in the acute stage of albuminuria, all that we know of the state of the blood in the disease would lead to its disuse, as a remedy having a tendency to lead the case into the chronic form of the affection, by decreasing the proportion of red corpuscles in

the blood; and though I have occasionally observed benefit from the use of the lancet or cupping, I do not believe such treatment to possess any advantage over the diaphoretic plan; and unless rendered an imperative measure by the presence of high inflammatory complications, experience has made me averse to its use in every form of this disease. The strong objection to the use of mercury expressed by many writers on this subject, though it would appear justified by the results of some few cases which have been subjected to the mercurial influence, is not so strongly impressed upon my mind as to induce me altogether to reject it as a remedy in acute cases, even when no complications exist. It appears to relieve the kidney greatly, but care must be used in its exhibition; and very small doses of mild mercurials are sufficient for the required purpose, as this mineral produces its effects very rapidly in albuminuria, occasionally causing profuse ptyalism when not more than two or three grains of calomel have been taken by the patient. In the more chronic form of albuminuria the employment of diaphoretics is of almost as much importance as in the acute disease; but it now becomes necessary to avoid their use to such an extent as to produce a depressing effect on the system. Patients on whom we are inducing diaphoresis, either by means of antimony, ipecacuanha, or any other medicine, should be constantly watched, and the remedy discontinued on the first signs of remission in the power of the pulse.

The free use of purgatives is of the greatest importance when commencing the treatment of the chronic form of this disease, and is a most powerful means of lessening the painful tension of the skin produced by anasarcaous effusion, and often relieves the patient in a surprising manner from the dull sleepiness and tendency to coma, a cause for so much anxiety to the practitioner. The anæmia existing in this chronic form of albuminuria is best treated by those remedies known to influence the blood, and to assist in restoring it to its healthy constitution. When the first distress experienced by tense anasarca or pain in the loins is relieved by the use of diaphoretics and purgatives, the greatest benefit will accrue from the use of ferruginous medicines. The lactate of iron given three or four times a day in doses of

five grains, with columba or any mild tonic, I believe is better adapted to restore the patient than any medicine with which I am acquainted.

As regards local treatment directed to the kidney, the use of counter irritation is greatly to be advised in cases of chronic albuminuria which are not very advanced. Setons or issues in the lumbar region I have known to assist in obtaining an early recovery. Much has been said concerning the propriety of administering diuretic forms of remedy in albuminuria, and it would appear desirable in most cases to avoid them; indeed they will often be found to produce considerable distress when the pulse is hard, and the tendency to the excretion of large quantities of albumen is observed on examining the urine. In some advanced cases, however, I have seen digitalis in small dose combined with squills of service in relieving symptoms of ischuria and bronchitis; as a general rule, my conviction is that they are better avoided.



## CHYLO-SEROUS URINE.

THE chemical history of chylo-serous urine is given in the Appendix.

I have seen but one case of this disease, which is of rare occurrence in our climate, and more frequently observed in warmer latitudes. The pathology of the affection is exceedingly obscure, and is probably connected with the history of a subject as yet but imperfectly investigated; viz. the changes occurring in the circulation during the admission of chyle. It is well ascertained that the disease may exist for many years without creating much distress. According to an observation made by Dr. Prout, on the body of a patient who died of inflammation of the bowels while passing this kind of urine, it would appear that its presence is not necessarily connected with any appreciable organic lesion of the kidneys. No particular remedy or plan of treatment has exercised any special influence upon the disease, though benefit has been derived, as in most other cases, from carefully watching and treating symptoms.

The obscure pathology of this affection, and its rare occurrence in this country, induce me to pass it with this slight notice, notwithstanding that its connection with the subject of sanguification affords an inviting field for hypothetical reasoning.

## ON DIABETES.

THE urine passed in this form of disease contains sugar, and is of high specific gravity, being generally above 1030, and often as high as 1057. Dr. Prout states that he has seen it as low as 1015. It is but rarely, however, that it is observed even so low as 1025. Diabetic urine is of a pale straw colour, and clear, seldom depositing a sediment, and froths considerably when agitated. The quantity passed during the twenty-four hours is very great, varying however from four to thirty pints; the latter is an excessively rare quantity, and we shall seldom observe excretion to half the amount. The odour of diabetic urine is peculiar, resembling that of hay, but of a more pungent character.\*

When a deposit occurs in diabetes, it will generally be found to consist of lithic acid, and its presence is considered by Dr. Prout as a favourable symptom. We also occasionally meet with caseous matter as an urinary deposit, and when present it induces rapid fermentation. The proportion of urea in diabetic urine is generally diminished; and in the course of the disease that principle is not always excreted in normal quantity, notwithstanding the large bulk of urine discharged daily, and we are occasionally able to detect it in the blood of the patient. The microscopic appearance of the fungoid growth found diffused in diabetic urine is given on the Plate (fig. 15.)

At the commencement of diabetes the train of symptoms are as follows:—General dyspeptic lassitude after food, and occasional gastrodymia are observed, notwithstanding that the appetite is good, and sometimes excessive. The bowels are constipated, the pulse irritable, and the tongue coated with a white mucus, which, when removed, leaves a glossy red appearance of the organ. Pain in the loins is often

\* In some aggravated cases of diabetes, the weight of egesta absolutely exceeds that of the ingesta, a fact first clearly pointed out by Mr. M'Gregor.

present, and the skin is dry, yielding a white scurf on the least friction; the flow of urine is increased, and thirst is an early and prominent symptom.

This disease is very insidious at the commencement, and its symptoms are not unfrequently overlooked as those of common dyspepsia, generally owing, I believe, to the time required by the patient to become aware of the increased flow of urine, which is that feature of the disease most likely to attract the attention of the practitioner to the true nature of the case. Of the two symptoms most prominently marked, viz. the thirst, and the increased flow of urine, I believe the former will, however, more frequently serve to assist our diagnosis than the latter, for the reason that it more prominently affects the comfort of the patient, and is therefore more likely to be related as a symptom. It certainly has happened to myself to have had this urged upon my attention by patients, who made no allusion to diuresis until especial inquiries were directed to the point. The value of this indication cannot be too strongly impressed on the mind of the practitioner; and whenever dyspepsia is attended with thirst, it is right to examine the urine particularly.

When diabetes is an advanced stage, emaciation becomes a very prominent symptom. The tongue presents a peculiar dry and red appearance, and is sometimes cleft in rugæ, while aphthous inflammation affects the gums and mouth. The appetite is ravenous, and the breath possesses a peculiar odour, while the urine passed is in large quantity and of high specific gravity. There is also a general feeling of lassitude, and occasional giddiness, with a tendency to sleep during the day. The venereal appetite is frequently deficient. These symptoms increase, and death is most commonly occasioned either by an attack of effusion on the brain, gradually ushered in by coma, or by the supervention of phthisis, a frequent complication of this disorder.

Post-mortem examinations have shown little else in this disease than enlargement of the kidneys, and a peculiar appearance of the blood, with some few of the ordinary effects of debility.

The general belief that diabetes is necessarily a fatal disease has in all probability arisen from the circumstance

that it was formerly seldom detected until far advanced, and beyond the reach of remedies.

Attention having been of late, however, more actively directed to the general subject of urinary disease, cases are earlier detected and subjected to treatment; and it now occasionally happens that we meet with patients with a well authenticated and old diabetic history, who, on examination, show no signs of diabetes, appearing to have been permanently cured, and who only apply to the medical man for complaints not necessarily connected with the original malady. I am now attending a case of this description. The causes producing diabetes have been stated very variously by writers. Mercurial erythism and inherited taint, either scrofulous or directly diabetic, are quoted as predisposing to the disease; but, with the exception of the latter, the causes noticed appear merely such as tend to the development of general debility.

Among the exciting causes, Dr. Prout enumerates mental anxiety; and every one who has seen much of this disease will agree that mental distress is often a part of the past history of diabetic patients. In the present state of our knowledge, however, we are unable to trace this disease to any very especial cause.

The observations which have been made on this disease in all its relations and in every stage have not yet been rewarded with success, so far as regards obtaining a knowledge of its true nature.

A near approach to this, however, has been made by Mr. M'Gregor; who, in several valuable communications laid before the profession, has shown that sugar is developed in diabetes during digestion, having succeeded in obtaining it from fluid vomited after a meal. This is a very valuable point to have decided; and it seems to prove that either the stomach or salivary glands must be seriously involved, since the food has only been subjected to the action of the secretions of these organs, when sugar admits of detection in considerable quantity.

In connection with this subject, I now have to notice the observations of M. Mialhe, which are replete with interest so far as regards the formation of sugar in the stomach. M. Mialhe has proved that in the digestion of amylaceous and

saccharine ingesta the saliva takes a prominent part; and he has separated from that secretion a substance analogous to diastase, to which he gives the name of animal diastase. This principle decomposes starch into dextrine, and requires a very short time for the purpose, as he proves by the blue colour of iodide of farina, not being produced when starch is submitted to the action of the diastase, and iodine is subsequently added. The importance of this discovery, with reference to the pathology of diabetes, will at once occur to every mind; and if this constituent of the saliva is alone concerned in the digestion of amylaceous and saccharine ingesta, or in any way necessary to the result, it would seem that the disease should be investigated with relation to the condition of the salivary glands; a point of view in which it has never yet received the attention of pathologists. M. Mialhe, in a paper on diabetes, has stated it as his belief, that saccharine and amylaceous principles are partly assimilated by an action consequent on admixture with the alkaline matters of the blood. It appears, however, according to the experiments of MM. Bernard and Barreswil,\* that if sugar is injected into the blood, it is passed as such by the kidneys; while, if it first be subjected to the action of the gastric juice, it cannot be detected in the urine; which shows that the alkali of the blood alone is insufficient to effect the transformation.

It is pretty certain that the stomach of every animal during digestion contains saliva as well as gastric secretion; and it appears, therefore, very likely, that the diastase of the saliva effected the transformation in the experiments of MM. Bernard and Barreswil, and not the gastric juice.

In taking this as a guide to the pathology of diabetes, we have as yet little but chemical evidence to assist us. It is clear, however, that sugar in diabetic cases is first formed in the stomach when amylaceous ingesta are taken; and, therefore, that either pepsin or salivary diastase fail in their action, or are not present to assist in digestion; and the experiments of M. Mialhe seem clearly to point to the action of saliva as the active means of effecting the transformations of health.

\* *Comptes Rendus*, Dec. 7. 1843, and April 15, 1844.



It has often appeared to me that the importance of the saliva has been underrated. The large quantity secreted and poured into the stomach during a meal, and the existence of a substance closely resembling, if not absolutely identical with, salivary matter in the chyle of animals, would seem to indicate that it plays some more important part in the economy than any with which we have yet become acquainted. The obscurity still involving the pathology of diabetes entitles every suggestion connected with it to the most attentive consideration of the practitioner; and the state of the salivary glands and their secretion will, I trust, before long, be fully investigated in this disease. There is a fact connected with the history of diabetes, which I have several times had occasion to observe; it is that on some days, and that too in advanced cases, the sugar is not to be detected in the urine, while the high specific gravity of the secretion is kept up by the presence of an enormous excess of urea taking as it were the place of the sugar. I believe this has been observed before by others. During some experiments I made on the use of oxalic acid in diabetes, I observed this alternation of urea and sugar to occur very frequently, and was inclined at the time to regard it as an effect of the remedy; but I have since known it to occur without any acid form of medicine having been prescribed.

The treatment of diabetes proposed from time to time has varied greatly in character. It is true that for the most part it has agreed in the one particular, in consisting of means directed to the stomach; but still some of those remedies considered as the most efficacious have been such as in health greatly tend to the derangement of that organ. Among the most powerful of these may be placed opium, which, in combination with other medicines, is frequently of service in checking symptoms, and has occasionally been known so far to restore the patient as to justify a hope that permanent benefit had been obtained. As regards the stomatic remedies, we find the alkalies and acids have both been fully tried; and the alkaline earth magnesia is still highly prized, as of service in this disease, by many experienced practitioners. Nitric acid has enjoyed an equally high reputation in the hands of others; and I have recently



seen apparent advantage derived from the continued use of hydrochloric acid. It has always appeared to me, however, that the cases most benefited by treatment have been those in which no special regard has been paid to a specific remedy, but where general principles have been carried out steadily, and so as to meet every emergency as it arose. The use of opium, though it is always found to diminish the quantity of water excreted, can in no way be regarded as an advisable measure, if the drug be exhibited in its uncombined state. Large doses become eventually necessary to keep up the effect first produced; and whatever apparent benefit may be observed in the secretion of the kidney, we find the general symptoms of the disease become aggravated, and, moreover, that considerable difficulty is experienced in desisting from the use of the remedy. The Dover's powder is a favourite medicine in this disease; and I have constantly seen the greatest benefit follow its use, and considerable relief afforded to the patient by its bringing about the partial restoration of the function of the skin. In acute cases, when pain is felt in the loins or head, the use of this remedy, combined with the hydrargyrum cum cretâ, in small divided doses taken during the day, will be found a most valuable means of decreasing action, and with the use of moderate bleedings greatly to assist in affording relief to drowsiness which forms a distressing symptom in some cases.

In addition to the above remedies, I know of none more applicable in the chronic form of the affection than magnesia taken frequently during the day. Warm bathing at intervals of a day or two is of great assistance; and if we can sufficiently restore the powers of our patient, this may afterwards be replaced by cold sponging, or the shower-bath. It is absolutely necessary, however, that the pulse should improve, and the power of undergoing fatigue have increased, before the skin is called upon for this re-action, and the cold bath should always be taken immediately on rising from bed, when the powers of life are recruited and in full vigour. Among the tonics which have acquired credit in the treatment of diabetes, are several metallic salts; the sulphates of zinc and iron, and the phosphate and lactate of the latter, have been used with benefit. Various vegetable tonics have also at times flattered the practitioner

into a belief of their efficacy. Whatever may be the plan adopted, however, one important indication should never be lost sight of, and that is, the constipated state of the bowels almost always observed in this disease.

The importance of attending to this point will at once be obvious, when we remember the emaciation so characteristic of this affection, and the propriety of affording as large a surface of intestine as possible for lacteal absorption, which cannot take place if the intestinal canal be obstructed. As regards the diet best suited to this form of disease, it appears any thing but reasonable to subject the stomach to the severe discipline which has been applied by the fashion of the day in prohibiting the use of vegetable food, and restricting the patient to a purely animal diet.

All the benefit derived from this plan of treatment consists in the fact that the profession are now well aware that the diabetic stomach will not convert fibrinous and albuminous ingesta into sugar, but that any advantage has accrued to the patient is greatly a matter of doubt. Several cases which I have seen do best have not been so restricted as regards vegetable aliment, but have been fed upon a wholesome, mixed, but restricted diet. The patient should be allowed his ordinary food, unless it be of a nature obviously calculated to produce or maintain dyspepsia ; the restriction being made in quantity rather than in quality or proportion. As regards drink, not only much good, but agreeable relief from thirst, is to be obtained from the use of Seltzer water, the salts contained in it probably exercising an immediate influence on the condition of the blood. Wines, spirits, and beer, should be avoided in the more acute forms of this disease, but they become necessary to maintain power in the advanced stages.

## ON EXCESSIVE EXCRETION OF UREA.

THERE is a condition of system characterised by the excretion of large quantities of urea, which is sometimes accompanied by an excessive quantity of water, thus occasionally leading to a suspicion that the individual is the subject of diabetes. The specific gravity of the urine in this disease varies greatly, but it is generally above that of health ; and when such is the case, we obtain a copious and almost immediate crop of crystals of nitrate of urea, on the addition of an equal bulk of nitric acid to the urine. This crystallization nearly always occurs if the urine be above 1030 in specific gravity. When a large quantity of water, and, consequently, urine of a low specific gravity, is passed, the *relative* proportion of urea in the excretion is of course not increased, and may even be diminished ; but in all cases the *absolute* quantity excreted during the day is greater than in health. Nothing is satisfactorily ascertained concerning the causes of this tendency to increased excretion. The symptoms of this disease do not differ particularly from those observed in ordinary cases of dyspepsia : there is, however, sometimes a frequent desire to pass urine. It is not uncommon to find the skin greatly in fault, and attention to the restoration of its function is always necessary as a first part of our treatment. This is especially desirable when the quantity of urine passed is large, and the specific gravity not above the healthy standard of 1022.

It is not often that we meet with this disease unless combined with an excessive discharge of water, for the reason that this is often the only urinary symptom to which the patient's attention can be directed, and the dread of diabetes induces him to apply for relief.

The waste of tissue shown by the large discharge of urea indicates the absolute necessity in these cases of abstaining from all causes calculated to induce an increase of that action ; and violent exercise and hard study should be

avoided as much as possible, while wines and beer, with a light diet of fish and vegetables, should form the dinner of such patients. Opiates have been found serviceable by Dr. Prout in this form of disease, and they are certainly often of great value, notwithstanding the prevalence of severe dyspeptic symptoms. The power they possess of restricting the rapid waste of tissue greatly assists in restoring the proportion of urea excreted to its normal standard. Mercurial alteratives with ipecacuanha or Dover's powder, according to the severity and duration of the disease, are among the most powerful remedies; but it is well to avoid opiates in early cases, which will generally be found to yield to purgatives, diaphoretics, and a restricted diet.

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## ON DEFICIENT EXCRETION OF UREA.

THIS disease, which has been called diabetes insipidus, to distinguish it from that form of excessive discharge from the kidneys known to contain sugar, is often confounded with those cases which have been treated of in the foregoing section, more especially when a large quantity of water accompanies the excess of urea. There is always a large excretion of urine in this disease, which, on being examined, sometimes shows a specific gravity as low as 1002. I have seen it 1001, but for the most part it is observed at from 1002 to 1008. The proportion of urea is not only relatively small in this urine, but the quantity excreted is absolutely less than in health, notwithstanding the enormous quantity of urine poured from the kidney. From six to ten pints are commonly excreted in the twenty-four hours, and cases are recorded in which as much as twenty pints have been noticed. The dyspeptic symptoms are generally severe in this affection, and great thirst is always present, with a dry skin and red tongue, while the appetite is irregular. The bowels are constipated, and there is pain in the head and drowsiness, with mental depression, and

sense of fatigue on the slightest exertion. The predisposing and exciting causes of this disease are not well ascertained, nor has its pathology been satisfactorily investigated. When large quantities of urine of very low specific gravity are passed, and there is great roughness of skin, the case may be looked upon as of very serious character, and the greatest difficulty will be encountered in affording relief. When, however, the symptoms are less severe, the following plan of treatment frequently relieves the patient: the skin should be kept clean by warm baths, while antimonials with small quantities of hydrargyrum cum cretâ are given at night. The bowels must be kept freely open, which is best effected by an aperient senna draught in the morning, which should not contain any saline purgatives in admixture, as they tend to aggravate thirst. Twice during the day a full dose of infusion of cascarrilla or gentain will assist the treatment. I have lately attended a case of this disease in which hippuric acid was passed in the urine to the entire exclusion of lithic acid, and am inclined to believe, that in many of these cases characterised by a cloudy urine of very low specific gravity the hippuric acid will hereafter be found to exist. Should this prove to be the case, it may perhaps assist us in acquiring a clue to the pathology of the disease.\*

\* A case has lately been read before the London Medical Society by Dr. Garrod, in which a very large quantity of hippuric acid was found to exist in the urine. Lithic acid was, however, also present in considerable proportion in this case.

## APPENDIX.

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### ON LIME AND MAGNESIA, WHEN THEY EXIST TOGETHER IN COMBINATION WITH PHOSPHORIC ACID.

THERE are some difficulties attending the chemical examination of these mixed phosphates, owing to the great similarity of re-action which exists between them ; and we have not yet arrived at any well-ascertained method of performing their quantitative separation. The nearest approach, however, is by the following process :—

The mixed phosphates are dissolved in dilute hydrochloric acid, and the solution is then nearly neutralised by ammonia. Alcohol is next added to the solution, and sulphuric acid carefully dropped into the mixture. In this way we precipitate a sulphate of lime of considerable purity, which must be collected on a filter, and washed with dilute acid and water which has been digested on sulphate of lime. By this means we remove any magnesian salt which may adhere. The sulphate of lime may now be dried and weighed ; and from its weight we may deduce that of the lime, and also of the magnesia ; for the proportional constitution as phosphate being known, we are able to do so from our previous knowledge of the original weight of the mixture on which we operated.

#### *Magnesia.—Lime.*

The presence of lime and magnesia, when they exist as phosphates, dissolved in an acid, is easily proved by first precipitating the liquid (previously nearly neutralised by ammonia), with the solution of oxalate of ammonia, and allowing the precipitate to subside. The mixture should now be briskly boiled



to perfect the precipitation of the oxalate of lime ; the clear liquor is then to be poured off ; and if the oxalate ceases to produce a further effect,\* we must add ammonia. Should we now observe a precipitate to occur, we may be sure that magnesia is present in the solution. When phosphate of iron exists in admixture with these earths, as is the case in the ashes of blood, we can easily prove its presence by testing the solution with the ferrocyanuret of potassium, which yields a fine blue precipitate of prussian blue.

The following substances have been noticed in minute quantity in the blood : viz. silica, manganese, copper, and titanitic acid. An account of my experiments regarding the presence of the last-mentioned substance may be seen in the *Philosophical Magazine* for March, 1835.

Marchand denies the existence of titanium in the blood ; the blowpipe re-actions, however, which I have obtained from the ashes of blood, are not such as I have ever been able to produce with any other substance than titanium.

### *Fatty Matters of the Blood.*

Besides the fatty matters which are contained in the serum of blood, and which were first pointed out by Dr. Babington, we can procure others by the action of ether on the mixture of fibrin, albumen, and red particles. The best process for preparing these fats is as follows :—

Let a quantity of fibrin, albumen, and red particles, be well dried, and then pulverised. Alcohol is now to be boiled on the powder, by separate portions, until the last added possesses no solvent action on the mass, which may easily be known by evaporating a portion of the fluid to dryness ; when, if no residue be observed, we may be sure that the action is complete.

The alcoholic solutions are now to be added together, and evaporated to half, when we frequently can observe that red particles become precipitated : in order to render this precipitation more complete, we must add a portion of cold alcohol to the warm fluid, when we shall perceive that a precipitate im-

\* Should the oxalate of ammonia continue to precipitate the solution, we must add an excess, and again allow the precipitate to subside before testing for magnesia with the ammonia. The magnesian precipitate frequently requires some time for its formation.

mediately collects, and the supernatant liquor becomes yellow.\* This clear liquor may be removed by a pipette, and left to spontaneous evaporation: as the alcohol dissipates, we shall observe a precipitate of a firm white fatty matter; this may be removed, and set aside; the clear liquor must now be evaporated to dryness, when we shall procure a fat of reddish tint, which, from its containing phosphorus, has been called the red phosphorised fat. It has no very peculiar properties: when heated it becomes of a dark-reddish colour, and its cinder has an acid re-action. It contains both sulphur and phosphorus. It does not saponify with the alkalies.

The solid white fat which separated from the alcoholic solution also contains phosphorus and sulphur; it has been named the white phosphorised fat: its re-actions are very similar to those of the red fatty matter. The alkalies possess no solvent action on this substance.

Cholesterine has been rejected from the list of constituents of healthy blood, in the admirable work of P. S. Denis; but there are many re-actions procurable from the crystalline fatty matter, which much resemble those of cholesterine; and if it be not that substance, I cannot but think that at least it is an incipient form of the biliary fat which exists in the blood.

\* This precipitate contains the fatty matter called serolin.

ON THE VARIABLE PROPORTIONS OF THE CONSTITUENTS OF THE  
HUMAN BLOOD.

The extensive researches of M. Lecanu have led him to the following results, which I here append in a table, together with a translation of his observations on the subject:—

“The proportion of water varies in the blood of individuals of different sex and age.	<p>From 853·135, maximum quantity of water contained in 1000 parts of blood, to 778·625, the minimum,</p> <p>Difference 74·510 Mean - 815·880</p>																														
In the blood of individuals of the same sex, but of different ages.	<p>From 853·135, maximum quantity of water contained in 1000 parts of female blood, to 790·394, the minimum,</p> <p>Difference 62·741 Mean - 821·7645</p>																														
The proportion of water is less in man than in woman.	<p>And from 805·263, maximum quantity of water contained in male blood, to 778·625, minimum,</p> <p>Difference 26·638 Mean - 791·944</p> <p>Mean proportion of water in woman's blood - 821·7645 Mean proportion in man - 791·9440 Difference of excess in woman's blood - 29·8205</p>																														
The quantity of water is not proportional to the age, at least from 20 to 60 years old, among individuals of the same sex.	<table> <tr> <th>1000 parts of blood, from females, have yielded of water:—</th><th>1000 parts of blood, from males, have yielded of water:—</th></tr> <tr> <td>at 22 years 853·135</td><td>at 26 years 790·900</td></tr> <tr> <td>25 796·175</td><td>26 778·625</td></tr> <tr> <td>34 801·918</td><td>from 30 to } 788·323</td></tr> <tr> <td>36 799·230</td><td>32 years } 785·881</td></tr> <tr> <td>38 827·130</td><td>at 32 years 795·870</td></tr> <tr> <td>53 790·840</td><td>34 782·271</td></tr> <tr> <td>54 799·432</td><td>from 38 to } 783·890</td></tr> <tr> <td>58 790·394</td><td>40 years } 780·211</td></tr> <tr> <td>58 792·897</td><td>from 45 to } 805·263</td></tr> <tr> <td>60 792·561</td><td>48 years } 801·871</td></tr> <tr> <td></td><td>from 48 to }</td></tr> <tr> <td></td><td>50 years }</td></tr> <tr> <td></td><td>from 62 to }</td></tr> <tr> <td></td><td>64 years }</td></tr> </table>	1000 parts of blood, from females, have yielded of water:—	1000 parts of blood, from males, have yielded of water:—	at 22 years 853·135	at 26 years 790·900	25 796·175	26 778·625	34 801·918	from 30 to } 788·323	36 799·230	32 years } 785·881	38 827·130	at 32 years 795·870	53 790·840	34 782·271	54 799·432	from 38 to } 783·890	58 790·394	40 years } 780·211	58 792·897	from 45 to } 805·263	60 792·561	48 years } 801·871		from 48 to }		50 years }		from 62 to }		64 years }
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In individuals of the same sex, there is less water in the blood of those possessing a sanguine temperament than in that of those of a lymphatic temperament.

In 1000 parts of blood from females:—

Sanguine tempera- ment.	Lymphatic tempera- ment.
Water 796.175	Water 790.840
792.561	827.130
792.897	801.918
790.394	799.432
	799.230

Mean of sanguine temperament	-	793.007
Mean of lymphatic temperament	-	803.710
Difference of excess for lymphatic temperament	-	10.703

1000 parts of blood from males yielded:—

Sanguine tempera- ment.	Lymphatic tempera- ment.
Water 780.210	Water 805.263
783.890	795.870
801.871	
778.625	
788.323	

Mean of sanguine temperament	-	786.584
Mean of lymphatic temperament	-	800.5665
Difference of excess for lymphatic temperament	-	13.9825

The proportion of albumen varies in the blood of individuals of different sex and age.

From 78.270, maximum quantity of albumen in 1000 parts of blood, to 57.890, the minimum,  
Difference 20.380  
Mean - 68.080

In the blood of individuals of the same sex, but of different ages.

From 74.740, maximum quantity of albumen contained in 1000 parts of blood from women, to 59.159, the minimum,  
Difference 15.581  
Mean - 66.9495

The quantity of albumen bears no proportion to the age, at least within the limits of from 20 to 60 years, in individuals of the same sex.

From 78.270, maximum quantity of albumen contained in 1000 parts of blood from men, to 57.890, the minimum,  
Difference 20.380  
Mean - 68.080

1000 parts of blood, from females, have yielded, of albumen.	1000 parts of blood, from males, have yielded, of albumen.
at 22 years, 68.756	at 26 years, 71.560
25 73.065	26 62.949
34 59.159	from 30 to } 71.061
36 60.125	32 years }
38 69.100	at 32 years, 64.790
53 71.180	34 78.270
54 74.740	36 66.090
58 70.210	from 38 to } 57.890
59 72.796	40 years }
60 69.082	from 45 to } 71.97
	48 years }
	from 48 to } 65.133
	50 years }
	from 62 to } 65.389
	64 years }

It is almost the same in proportion for individuals of sanguine and lymphatic temperaments, of the same sex.

In 1000 parts of blood from females:—			
Sanguine tempera- ment.		Lymphatic tempera- ment.	
Albumen	73·065	Albumen	71·180
	69·082		69·100
	70·210		59·159
	72·796		74·740
			69·125
Mean of sanguine temperament		-	71·264
Mean of lymphatic temperament		-	68·650

In 1000 parts of blood from males:—			
Sanguine tempera- ment.		Lymphatic tempera- ment.	
Albumen	71·970	Albumen	65·133
	57·891		78·270
	65·389		
	62·949		
	71·061		
Mean of sanguine temperament		-	65·85
Mean of lymphatic temperament		-	71·7015
Difference		-	5·8515

The proportion of globules varies in the blood of individuals of different ages and sex.

From 148·450, maximum quantity of globules contained in 1000 parts of blood, to 68·349, the minimum,

Difference 80·101  
Mean - 108·3995

Also in the blood of individuals of the same sex, but of different ages.

From 148·450, maximum quantity of globules contained in 1000 parts of blood from males, to 115·850, the minimum,

Difference 32·60  
Mean - 132·150

The proportion of globules is greater in men's blood than in that of women.

From 129·999, maximum quantity of globules contained in 1000 parts of blood from females, to 68·349, the minimum,

Difference 61·641  
Mean - 99·1695

Mean of female blood - - - 99·1695  
Mean of male blood - - - 132·1500  
Difference of excess in male blood - 32·9805

The quantity of globules does not appear to be proportional to the age in individuals of the same sex within the limits of from 20 to 60 years.

1000 parts of blood from females have yielded, of globules,	1000 parts of blood from males have yielded, of globules,
at 22 years, 68·349	at 26 years, 128·670
25 121·720	26 146·885
34 129·610	from 30 to } 131·688
36 119·000	32 years } 139·129
38 92·670	at 32 years, 115·850
53 129·990	34 141·290
54 115·319	36 from 38 to } 148·450
58 127·730	40 years } 133·820
58 125·590	from 45 to } 117·484
60 129·654	48 years } 121·640
	from 48 to } 117·484
	50 years } 121·640
	from 62 to } 121·640
	64 years }

In individuals of the same sex, the proportion of globules is greater in those of a sanguine than in those of a lymphatic temperament.

1000 parts of blood, from females, yielded :—	
Sanguine tempera- ment.	Lymphatic tempera- ment.
Globules 121·720	Globules 129·990
129·654	92 670
127·730	129·610
125·590	115·319
	119·000
Mean of sanguine temperament	- 126·174
Mean of lymphatic temperament	- 117·300
Difference of excess in sanguine temperament	} 8·874

1000 parts of blood, from males yielded .—	
Sanguine tempera- ment.	Lymphatic tempera- ment.
Globules 133·820	Globules 117·484
148 450	115·850
121·640	
146·885	
131·688	
Mean of sanguine temperament	- 136·497
Mean of lymphatic temperament	- 116·667
Difference of excess in sanguine temperament	} 19·830

On these results, the following remarks are made by Monsieur Lecanu :—

1. “The proportion of serum varies in the blood of individuals of different sex and age ; also in the blood of individuals of the same sex, but differing in age.” It is greater in the blood of women than in that of men. It is also greater in the blood of lymphatic individuals than in that of those possessing a sanguine temperament, the sex being the same. No relation is to be observed between the quantity of serum and the age of individuals of the same sex, at least within the limits of from twenty to sixty years old.

2. The proportion of albumen, fibrin, and colouring matter—in other words, the nutritive substances—varies in the blood of individuals of different sex and age. In the blood of individuals of the same sex, but of different age, it is less in the blood of women than in that of men ; and also less in the blood of lymphatic persons than it is in the blood of those possessing a sanguine temperament, the sex being the same. No relation is to be observed between the quantities of nutritive matters and the ages of individuals of the same sex, at least within the limits of from twenty to sixty years.

As regards the serum (essentially formed of water and albumen,) the proportion of water, and, consequently, that of the albumen, varies in individuals of different sex and age. In individuals of the same sex and of different ages, it appears to be nearly the same in men as in women, and in individuals



of sanguine and lymphatic temperament. In relation to the analysis of the blood of females, it must be observed that the menstrual losses to which they are subject contribute especially to vary the proportion of globules; thus the analysis of the blood of a female affected with the uterine discharges afforded in a first experiment.—

Water	-	-	-	-	851·590
Albumen	-	-	-	-	66·870
Soluble salts and extractives	-	-	-	-	11·290
Globules	-	-	-	-	70·250
<hr/>					
Total	-	-	-	-	1000·000

And in a second experiment—

Water	-	-	-	-	832·754
Albumen	-	-	-	-	60·891
Soluble salts and extractives	-	-	-	-	13·210
Globules	-	-	-	-	93·145
<hr/>					
Total	-	-	-	-	1000·000

That is to say, in these two cases, and especially in the first, the quantity of globules was only about half that observed in the other analyses of woman's blood.

It is easily foreseen that a similar effect to the above may be produced by repeated bleedings. Thus, the woman who was the subject of the sixteenth experiment, having been blooded for the third time, I found that the blood, instead of containing as before—

Water	-	-	-	-	792·897
Albumen	-	-	-	-	70·210
Soluble salts and extractives	-	-	-	-	9·163
Globules	-	-	-	-	127·730
<hr/>					
Total	-	-	-	-	1000·000

Contained only—

Water	-	-	-	-	834·050
Albumen	-	-	-	-	71·111
Soluble salts and extractives	-	-	-	-	7·329
Globules	-	-	-	-	87·510
<hr/>					
Total	-	-	-	-	1000·000

The proportion of albumen in the serum shows much less sensible variation in cases of successive bleedings or uterine discharges; which is easily conceived, since the liquid, absorbed at the expense of the whole system, and proportionably to the blood drawn or discharged, is water charged with albumen."

I shall now append a statement of the inferences which have been drawn by various other experimenters, as the result of their researches into the constitution of the blood under different conditions both in health and disease.

### *Arterial and Venous Blood.*

Simon states that arterial blood contains more water than venous blood, and that the blood corpuscles of arterial blood contain less colouring matter than those of venous blood.

Denis did not detect more water in arterial than in venous blood, but found them alike in this respect.

Hering examined the arterial and venous bloods of several animals, viz. the bullock, the sheep, and the horse, and agrees with Simon in making arterial blood to contain more water than venous.

Hering states the corpuscles in venous blood to exceed in number those of the arterial.

Lecanu differs from all the foregoing chemists in finding a smaller proportion of water to exist in arterial than in venous blood—he also found a larger proportion of fibrin in the arterial blood.

Simon, Denis, and Hering could discover no law as to the proportion of fibrin; sometimes it was in larger proportion in the arterial, sometimes in the venous blood.

The evidence of other chemists is very conflicting as to the relative proportions of water and fibrin. There appears to have been some modifying cause in action to produce these discrepancies, and which has been entirely overlooked; probably the time allowed to elapse after taking food before the blood was drawn may have caused these differences in result.

### *Blood of the Vena Portæ.*

Schultz has experimented on this blood as obtained from the horse. He states it to be of a much darker colour than ordinary

venous blood ; but that it becomes brighter after a full meal. The neutral salts and atmospheric air do not brighten the colour of portal blood. Simon analysed the arterial and portal blood of a horse, and concludes from his experiments that portal blood contains less fibrin, more fat, more extractives and salts, and more colouring matter in proportion to globulin than arterial blood.

*Blood from the hepatic Vein.*

This blood has been examined by Simon, who concludes from his analyses that it is richer in solid constituents than either ordinary venous or arterial blood, even more so than that taken from the vena portæ. It contains less fibrin, fat, globulin, and colouring matter than the blood of the vena portæ.

*Blood from the renal Veins.*

This blood has been shown by Simon to contain more solid constituent and albumen than that of the aorta, but it contains less fibrin and fewer corpuscles.

*Blood from the Capillaries.*

Pallas analysed blood taken by leeches and cupping, and by comparing his results with the analyses of venous blood, came to the conclusion that capillary blood is richer in solid and coagulable constituents than either venous or arterial blood. Denis contradicts this, having found that blood taken from the arm and compared chemically with that taken from the side of the chest of the same person by cupping, yielded results almost identical in the proportions of water, corpuscles, and solids of serum.

*Blood of the Fetus compared with that of the Mother.*

Denis found the blood of the fœtus to contain more solid matter and corpuscles than that of the mother. The fœtal blood contains more iron than that of the mother, the ratio being 2·5 to 1. His analysis was made on blood taken from the umbilical artery, and is compared with the analysis of the venous blood of the mother.

*Influence of Blood-letting.*

Becquerel and Rodier have made a great number of analyses of the blood of persons who have undergone repeated venesection. From the tables they have constructed it appears that loss of blood is followed by a decrease in the specific gravity of the circulating fluid. The albumen diminishes very slowly. The fibrin is not much influenced, the extractives and salts are unaltered, the fat is diminished, the corpuscles are greatly decreased in number.

*Blood in Inflammation.*

Andral and Gavarret have established, by analysis, the fact, that the proportion of fibrin is greatly increased in inflamed blood. Becquerel and Rodier have also shown this to be the case, and, moreover, have established, that the proportion of albumen in such blood is less than in the healthy state.

*Blood in Phthisis.*

Andral and Gavarret state that as this disease advances the proportion of fibrin increases, and that of the corpuscles decreases. In extreme cases, however, the whole blood becomes impoverished.

*Blood in Puerperal Fever.*

According to an analysis of this kind of blood made by Heller, the fibrin was increased beyond the normal standard, and the corpuscles greatly decreased in number.

*Blood in Typhus fever.*

The general results of Andral and Gavarret show that in this disease the proportion of fibrin in the blood decreases, while that of the corpuscles increases.

Becquerel and Rodier analysed the blood of eleven men affected with typhoid fever, and obtained the following as the mean composition of their blood:—

Water	-	-	-	-	797
Fibrin	-	-	-	-	2.8
Albumen	-	-	-	-	64.8
Fat -	-	-	-	-	1.7
Corpuscles	-	-	-	-	127.4
Extractives and Salts			-	-	6.3
					<hr/>
					1000.0

Here we observe the fibrin and corpuscles in about normal proportion, while the albumen is only very slightly decreased.

Scherer found the salts of blood in typhoid fever to amount to 11.92 per 1000, which is an increase on the proportion of salts in health. The alkaline salts alone amounted to 10 per 1000, while in health they never amount to 9 per 1000.

### *Blood in simple continued Fever.*

Andral and Gavarret have shown that in this disease we generally have a slight increase in the proportion of the fibrin of the blood, and a decrease in that of the corpuscles. When inflammatory complications occur in the course of this disease, however, we find the fibrin increasing very greatly indeed, while the corpuscles decrease to the proportion observed in inflammatory affections generally.

In three analysis made by Becquerel and Rodier, the albumen and fibrin of the blood from a case of continued fever were in healthy proportion, while the corpuscles were slightly above the average weight in health.

### *Blood in intermittent Fever.*

Andral and Gavarret have examined the blood in ague, and found an excess of fibrin and decrease of the proportion of the corpuscles. No difference was observed in the blood whether drawn during the hot or cold stages, or during the remissions.

### *Blood in Scarlatina.*

Andral and Gavarret give the three following analysis of the blood in this disease:—

Water.	Fibrin.	Corpuscles.	Solids of Serum.
761.5	3.1	146.0	89.4
776.3	3.5	136.1	84.1
798.3	6.8	112.2	82.7

### *Blood in Apoplexy.*

Andral and Gavarret state that in the greater number of cases of cerebral apoplexy, the proportion of fibrin in the patient's blood is deficient, and the corpuscles in excess.

The following is the mean of twenty-one analyses made by Andral and Gavarret of blood taken from patients suffering cerebral congestion, threatening apoplexy. It is compared with healthy blood.

	Water.	Fibrin.	Corpuscles.	Solids of Serum.
Mean -	787.1	2.6	120	89.7
Healthy blood	790	3.0	127	80

### *Blood in Chlorosis.*

An analysis of this kind of blood by Dr. Vetter showed the proportion of corpuscles to be greatly diminished, the water in excess, and fibrin in about normal quantity.

Andral and Gavarret have analysed the blood of chlorotic patients, both at the commencement of the disease, and when it has advanced.

The mean of eight analyses of the first kind of blood, and nine of the second, is compared below with the blood in health.

	Water.	Fibrin.	Corpuscles.	Solids of Serum.
Health -	790	3	127	80
Insipient chlorosis	801	3.5	106.8	88
Advanced chlorosis	853.2	2.9	56.7	88

### *Organic Acids of Urine.*

Besides the acids which have been treated of as existing in this excretion, we have to notice the following; viz.

Acetic.

Butyric.

Benzoic—hippuric or uro-benzoic.

These acids have not been much examined, and there is some contrariety of opinion regarding them. Thus, though Prout and Thenard admit the existence of acetic acid in urine, we find that Berzelius expresses a directly opposite opinion, and believes that the odour of the butyric acid mingled with that of hydrochloric acid has led to the error; for, on the addition of sulphuric acid to a dry mass containing a chloride and a butyrate, we have an odour evolved which simulates that of acetic acid. It is the opinion of Berzelius, that neither acetic acid nor acetates are to be detected in the urine; and Liebig has lately shown that acetic acid exists in urine only as a result of decomposition.

The butyric acid has been observed but in one specimen of urine, and it is a matter of doubt whether it be not rather an accidental than a necessary constituent of the fluid.

The benzoic acid was supposed to have been discovered in the urine of the cow by Rouelle. Liebig made some minute



investigations into the nature of this acid found in the urine, and has proved it to be a distinct acid from the benzoic—as its salts are less soluble in water, and it contains nitrogen, which the benzoic does not, being an oxide of a hydro-carbonous body, to which the name of benzule has been applied.

Liebig named this acid the hippuric, as he considered it peculiar to the urine of the horse; but this is not the case, as he has lately detected it in the urine of man. Berzelius calls it the uro-benzoic acid, which is certainly a more appropriate term. The salts formed by this acid have been examined and described by Berzelius.

When urine becomes stale it no longer contains hippuric acid, but benzoic acid becomes developed.

*Quantitative Estimation of Fixed Alkaline Chlorides, Phosphates, and Sulphates in the Urine.*

The residue of the incinerated urine contains these salts, which may be separated as follows:—

They are to be dissolved in distilled water, and the solution filtered. Half the filtered liquor is then rendered acidulous by the addition of a few drops of nitric acid. An excess of a solution of nitrate of barytes is now added. The precipitate is collected on a filter and dried perfectly; from the weight of this sulphate of barytes, we can deduce that of the sulphuric acid. The filtered liquor, which is acidulous, must now be saturated with ammonia, which lets fall a precipitate of phosphate of barytes; this is to be collected and dried on a filter; from its weight we can deduce that of the phosphoric acid.\*

It is to be remembered that we have here operated on half the liquor, and that, consequently, we must double our resulting quantity of sulphuric and phosphoric acids.

The remaining portion of the filtered liquor is used to determine the quantity of hydrochloric acid present in the salts, as follows:—

A solution of nitrate of silver is added to the liquid, previously acidulated with nitric acid. A chloride of silver now precipitates, which is to be collected on a filter, and then dried in a platinum crucible over the spirit lamp; from its weight we deduce that of the hydrochloric acid.

\* Care should be taken not to add too much nitric acid at the commencement of this process; for by this means we produce so much nitrate of ammonia, when we saturate, that the precipitated phosphate is liable to be dissolved.

Having ascertained the weight of the acids, we have but to add the correct proportions of alkali for neutral combination, in order to discover the quantity of each alkaline salt.

The sulphuric acid may here be divided between potash and soda.

The phosphoric and hydrochloric acids are in combination with soda only.

If we wish to ascertain the exact proportion of soda which exists in combination with the sulphuric acid, we must have recourse to precipitation by the chloride of platinum, on a known quantity of the saline solution, estimating the proportion of the alkali from the known constitution of the potash chloride of platinum.

### *Albuminous Urine.*

This form of diseased urine is generally coagulable by heat, and is for the most part acid. We, however, occasionally meet with specimens which are alkaline, and incapable of becoming coagulated by a boiling temperature. It was supposed that this depended upon the presence of some fixed alkali, which held the albumen in solution; and in order more thoroughly to examine the matter, I made analyses of two specimens of urine taken at different times from the same individual: the one was neutral and coagulable by heat; the other not coagulable by heat, and possessing an alkaline re-action. Both these specimens became coagulated on the addition of nitric acid.

1st specimen.—Neutral, coagulable by heat, as also on the addition of nitric acid.

Water	-	-	-	-	195·0
Albumen	-	-	-	-	1·1
Alkaline salts	-	-	-	-	1·4
Urea, ammoniacal salts, and extractives					2·2
Earthy phosphates, loss	-	-	-	-	0·3
					<hr/>
					200·0

2d specimen.—Alkaline, not coagulable by heat, but becoming coagulated on the addition of nitric acid—

Water	-	-	-	-	195.8
Albumen	-	-	-	-	1.7
Alkaline salts	-	-	-	-	0.5
Urea, ammoniacal salts, and extractives					1.8
Earthy phosphates and loss	-	-	-	-	0.2
					<hr/>
					200.0

It will be observed that the alkaline specimen contained the greatest proportion of albumen, and a much smaller proportion of alkaline salts, than the neutral urine. This would go strongly against the probability of any fixed alkali being the solvent of the albumen; for in this case we should expect a redundant quantity of fixed saline matter in proportion to the albumen present, whereas exactly the opposite was the case, in this specimen at least.

There has been said to exist in the urine an animal substance, to which the name of incipient albumen has been given. I do not believe in the existence of such a substance, and am of opinion that the fact of the precipitation of the earthy phosphates by heat led to the erroneous belief in the presence of such a body.

#### *Tests of the Presence of Albumen in the Urine.*

It is customary with practitioners to test for albumen in the urine by the application of heat, and the addition of nitric acid. I will now notice the sources of fallacy connected with the use of each test. The test of heat fails to show the presence of albumen when the urine is alkaline, and this is also the case in some neutral specimens, no opalescence being produced even at a boiling temperature. It is necessary, therefore, before using this test, to examine the state of the urine, as to acidity or alkalinity.

Specimens of urine, when possessing either an acid or alkaline re-action, will occasionally, when no albumen is present, become opaque when boiled, the flocculi produced simulating the appearance of albumen. This opacity is caused by the precipitation of the earthy phosphates which may be distinguished from albumen by becoming immediately dissolved on the addition of a drop of dilute nitric acid. These phosphatic specimens are not precipitated by nitric acid, and therefore this source of fallacy is removed by testing with that reagent. Nitric acid, however, is not in itself a satisfactory test for albumen, being productive of a source of fallacy in throw-

ing down lithic acid in large quantity from some kinds of urine. These instances are rare, however, and may be distinguished by the addition of hydrochloric acid, which throws down the lithic acid quite as completely as the nitric acid does, while such is not the case with albumen. From what I have related above, it will be perceived that it is quite possible to meet with a specimen of urine coagulable both by nitric acid and by heat, and which shall notwithstanding be free from albumen, for heat may throw down the phosphates, while nitric acid may cause a deposit of lithic acid. I once met with such a case. There is another source of error connected with testing urine for albumen by nitric acid, of which it is necessary that the practitioner should be aware, and I therefore here append a notice extracted from the Guy's Hospital Reports, in which I entered at full upon several questions connected with the chemical pathology of albuminous urine.

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In a recent number of the Medical Gazette, I noticed a peculiarity in the urine passed by patients taking copaiba; such urine becoming coagulated on the addition of nitric acid, notwithstanding that no albumen was present. Since the publication of my observations on those specimens, I have had several opportunities of examining the urine voided by patients to whom cubebs had been administered; and have found a curious similarity between the re-actions afforded by such specimens, and by those which were impregnated with copaiba.

The latter urine, which I have examined several times, always yielded a precipitate, on the addition of nitric acid: in some cases, this was very slight; but in the majority, very dense and white, and greatly resembling albumen. The action of the acid on urine impregnated with cubebs is precisely similar in character, excepting that the colour of the precipitate occasionally verges on a pale pink. Previous to my publishing the re-actions of copaiba, there was but one substance (albumen excepted) supposed to be precipitable from the urine by nitric acid: this was lithic acid, which, however, could not be regarded as a frequent source of fallacy; as, when thus precipitated, it seldom comes down till the tested liquid has been allowed to stand some time, and then appears in a semi-crystalline form, and of a brownish-red colour. The precipitate afforded by cubebs and copaiba is, however, of that cloudy opaque character which simulates albumen, and moreover occurs immediately on adding the test.

It became an object now, to discover some simple method of discriminating between this precipitate and that obtained by nitric acid from albuminous urine. Fortunately, a very easy means of doing so is afforded us, by allowing the urine to which the acid has been added to remain at rest for an hour or two; when, should the precipitate consist of albumen, it will be found to have collected at the bottom of the tube, or to be arranged in flocculi through the liquor, the greater part of which will appear clear. If, however, the precipitate be caused by the presence of a vegetable matter derived from copaiba or cubebs, the precipitate does not subside for several days; not, indeed, till decomposition has occurred. Another and more speedy method of discriminating between these two impregnations and albumen is by the use of the ferro-cyanuret of potassium as a precipitant, the urine being previously acidulated by acetic acid. If albumen now be present, it is immediately thrown down; but in the other cases, even if the acetic acid cause a slight turbidity, it is not increased by the addition of the ferro-cyanuret. It is interesting to observe how supposed exceptions to the law declared by Dr. Bright become explained away by advances in the chemical pathology of the urine; copaiba, for instance, has been stated to cause albuminous urine; and probably cubebs may also have been looked upon as capable of affording the symptom which Dr. Bright has regarded as characteristic of a peculiar morbid tendency in the kidney.

It is greatly to be regretted, that the tests both of heat and nitric acid are not applied to the examination of urine: both are certainly not generally used. Perhaps, where one test only is employed, that of heat is the most common, and the sources of fallacy above alluded to are therefore less likely to occur; but still there are many who use nitric acid exclusively, and such are not very unlikely to meet occasionally with the deceptive re-actions I have mentioned. On the whole, it would be far better, if one test only were applied, that it should be the nitric acid; for the phosphatic precipitates which so often occur on the application of heat to urine, and the suspension of albumen, even after long boiling in some alkaline specimens, tend to render this an exceedingly imperfect test. Now, nitric acid throws down but one precipitate, resembling albumen; and that not being a constituent of the urine, but a matter derived from ingesta, we are the less likely to encounter such source of error: and even when it occurs, a little patience, in watching the after-

behaviour of the precipitate, might occasionally betray the real cause of the re-action obtained.

Until very recently, it has been supposed, that if nitric acid and heat both caused a precipitate in urine, albumen must be present: this, though true in the general, is not strictly correct: and it is right to recollect, that we may have earthy phosphates precipitated by heat, while vegetable matters derived from ingesta may be thrown down by nitric acid. Such kind of urine lately occurred to me, while collecting specimens impregnated by cubebs. There is no doubt that until very lately such a case would have been confidently quoted as one in which albumen existed in the urine.

I must mention, that the conditions I have noticed are not always to be expected, either in the case of copaiba or cubebs; appearing most strongly when the urine smells powerfully of the drug, and being scarcely perceptible when the characteristic balsamic odour is wanting. I have reason to believe, that when either cubebs or copaiba are administered with an alkali, that the urine becomes more rapidly and completely impregnated; but it is difficult to conceive what cause can be in operation to produce an occasional difference in this respect, the urine suddenly becoming (even when large doses of the medicine are being exhibited) comparatively free from impregnation. The frequent occurrence of the earthy phosphatic precipitate afforded by the action of heat on urine, and, consequently, the fallacious nature of the test by heat, may be better appreciated, if I now lay before the reader a statement drawn up from some valuable Tables which were formed by Dr. Barlow and Mr. Tweedie, at the suggestion of Dr. Bright. I find, by examining these Tables—in forming which, the tests both of heat and nitric acid were used to ascertain the presence of albumen—that in 482 cases, taken promiscuously from the hospital wards, 34, or about 7 per cent., were found which coagulated or became opalescent by heat, while they were not affected by nitric acid: these, therefore, were cases in which the phosphates were precipitated; and had heat alone been used as a test for albumen, we now observe how many errors must have been committed, and how many cases might have been cited as exceptions to Dr. Bright's law. Though well aware of the frequent occurrence of this source of fallacy, still I must say, I was scarcely prepared to find it in so large a proportion of cases as 7 per cent. In Tables constructed by Dr. Barlow, in which he examined the urine of 300 individuals, we find that 1 in 11 had albuminous urine: other Tables make 1 in 6 as the proportion;



the former being about 9, and the latter nearly 17 per cent. This shows how impossible it is to arrive at a satisfactory approximation to the truth by the use of the test by boiling alone: for among 100 persons, 16 might be declared to have albuminous urine; and of these, only 9 might present the degeneration of kidney on post-mortem examination, the 7 cases opposing the general truth which the observer was seeking to confirm.

As it may be interesting to know the particulars of the cases showing the deposit of phosphates on the application of heat, I will give the names of the wards, and the number of cases found in each, with such particulars as the Tables afforded.

These observations were not all made at the same time; a considerable period having elapsed between the first and second examinations of the patients in those wards, the names of which occur twice in the following Table.

Name of Ward.	Cases yielding a Precipitate of earthy Phosphate on Application of Heat.	Number of Patients in the Ward.	OBSERVATIONS on Cases yielding the Precipitate.
Job - - -	3	22	} 1. Patient hemiplegic and cachectic from intemperance. 2. Fever. 3. Anasarca: hydrothorax worn by intemperance.
Martha - - -	0	30	
Name of Ward omitted in the Table	0	23	
Lazarus - - -	1	23	} Long an invalid, with chronic rheumatism and catarrh. 1. Boy with calculus, 2½ years old. 2. Worn and feeble: malignant disease. 3. Strumous, with hip-joint diseased. 4. Abscess in the mouth: somewhat emaciated. 5. Much depressed: paralysis. 6. Constipation: plethoric person.
Charity - - -	6	30	
Luke - - -	0	29	
Cornelius - - -	0	18	
Dorcas - - -	1	30	Axillary abscess.
Petersham - - -	2	17	} 1. Renal tumour: has suffered much pain. 2. Knee-joint disease: strumous. 1. Fractured tibia and fibula. 2. Burn: child 5 years old.
Esther - - -	2	13	
Lazarus - - -	0	22	
Job - - -	0	16	
Miriam - - -	0	8	
Mary - - -	0	20	
Mary and Dorcas	1	10	} Secondary symptoms: takes bichloride of mercury and sarsaparilla. 1. Tumour of thigh: operation. 2. No account. 3. Phthisis: hip-disease.
Martha - - -	3	25	
Naaman - - -	2	26	} 1. Amputation: takes ammonia. 2. Effusion: not mentioned into what cavity. 1. Boy 2½ years old: paralysis. 2. Long illness: takes calomel and opium; disease not mentioned. 3. Morbus cordis: has had rheumatism. 4. Pleuritis.
Charity - - -	4	28	
Cornelius - - -	3	15	} 1. Taking tonics and alteratives. 2. Old disease: asthma. 3. No history. 1. Abscess of leg. 2. Bad leg: is taking stimulants.
Dorcas - - -	2	26	
Two Tables without the names of Wards affixed	4	In the two Wards, 46	1. Scrofula. 2. Morbus cordis. 3. Paralysis and diseased vertebrae. 4. Amenorrhœa.

The examination of this Table becomes particularly instructive, as a warning to observers not to be too apt to draw conclusions from a few instances;—an error which is committed day after day in our profession, and which cannot be too often noticed and condemned. In this Table we have instances from Charity Ward of 6 patients out of 30; while, if we look to Luke's Ward, there is not a single case among 29. Again, in Martha Ward we do not find a case in 30; while in Esther Ward there occur 2 in 13. I need hardly say how completely 30 cases would have satisfied the minds of most inquirers as to the great rarity of these phosphatic cases; how, indeed, the question would be looked upon as well nigh settled; and a strong defence for the conclusion have been afforded, by the undeniable fact, that more than half the doctrines of medicine were based on a less substantial foundation. Here are 30 consecutive cases affording no instance. Now, let us suppose the inquiry to cease. What would be the impression on the mind of the observer not cognisant of the fact, that the next thirty might yield him 6 instances? To one entirely unacquainted with the variable nature of the functions of the body, 30 consecutive cases would be strong evidence. They might be strong evidence to the mathematical philosopher, who, if not a physiologist, would not duly appreciate the variations which so puzzle those who inquire into the more intimate parts of medicine. It may well be asked, If these varying causes are so numerous, how can we ever hope to arrive at a due appreciation of the value of our collected instances? The table above quoted is an answer to this question. It is only by such collected groups of facts, such as those of 30 here mentioned, that we can arrive at an estimation of the power of such varying causes, and, consequently, of the multiplicity of instances which may or may not be required, for satisfying the mind on any particular point; by making us feel a conviction, that the cases are sufficiently numerous to overpower the sources of fallacy. In the present inquiry, it was a difficult thing to conceive, that, after 30 cases were consecutively examined, and no result obtained, that the next 30 should yield us 6 instances: but having now ascertained this second result, we can bear in mind, that such groups may again occur (or something approaching to them) in future examinations connected with the pathology of the urine: and, by observing the limits of variation in a large collection of similar groups, we may hope eventually to arrive at something approaching to a correct estimation of the value of any number of instances which may be offered us as evidence,

by future observers. From the observations on the cases contained in the Table, I think it may be concluded that the phosphates are apt to be precipitated from urine, on the application of heat, in patients of a cachectic habit, and in those worn by disease and suffering. The specific gravity of such urine is often as low as 1010 and 1012: though this is not always the case, as we sometimes find it natural, viz. from 1017 to 1022. It has frequently been stated, that mercury, when administered in quantity, renders the urine albuminous. I was very anxious to put this to the test; and accordingly formed the plan of a Table which my friend Dr. D. Francis (who has attended much to the examination of diseased urine, and for whose accuracy and judgment I can vouch) kindly undertook to fill up with observations on those patients admitted into the hospital, who would probably be subjected to salivation. The urine of these patients was tested when salivation was complete, and, in some cases, before the administration of the remedy; the latter being necessary, to exclude cases of true Morbus Brightii, which would interfere with the inquiry.

I have great pleasure in being able here to quote the following results of Dr. Francis's labours:—

No. Name, Date and Disease.	Action on Litmus and Turmeric.	Effects of Heat.	Effects of Nitric Acid	S. G.	State of Gums.	Observations.
1. Benjamin Neale. Dec. 13. 14 Samaritan. Syphilis.	Acid	No change	No change	1016	Gums fairly affected; fætor: saliva increased	Urine was not examined previous to administering of mercury.
2. John Hart. Dec. 18. 30 Samaritan. Syphilis. Jan. 2.	Acid	No change	No change		Mouth not affected.	
	Acid	Lithates dissolved	No change	1022	Gums sore and turgid; fætor.	
3. Edward May. Dec. 18. 32 Samaritan. Syphilis. Jan. 6.	Acid	No change	No change		Mouth not affected.	
	Acid	Slight precipitate	No change	1021	Teeth loose. gums very sore; fætor: increased saliva	Precipitate by heat dispelled by nitric acid. Urine clear, copious, and natural in colour.
4. Edward Ford. Dec. 18. 18 Samaritan. Syphilis. Jan. 6.	Acid	No change	No change		Mouth not affected.	
	Acid	No change	No change	1004	Teeth loose: gums sore	Urine very copious, clear, and limpid.
5. Edward Bryant. Dec. 18. 9 Samaritan. Syphilis. Jan. 4.	Acid	No change	No change		Mouth not affected.	
	Acid	No change	No change	1024	Gums ulcerated: teeth loose	Urine natural in quantity and colour, and clear.
6. Mary Hart. Jan. 9 2 Ruth. Wound of the eye.	Acid	No change	No change	1009	Gums turgid and apthous: teeth loose: fætor	Urine copious and limpid: not examined previous to administering mercury: saliva slightly reddened litmus.
7. Celia Everett. Jan. 15. Ruth. Syphilitic iritis.	Acid	No change	No change	1005	Face and glands beneath the jaw swollen: teeth loose: gums very turgid and apthous	Urine rather copious, not examined before the mercurial influence: saliva slightly acid.

8. Jan 15. Naaman Cerebral disease,	Acid	No change	No change	1016	Gums turgid and ulcerated: factor: face swollen	Urine natural in appearance: not examined previously to exhibition of mercury: saliva neutral.
9. Thomas Wells, Jan. 9. 35 Samaritan. Syphilis, Jan 22.	Acid	No change	No change	1018	Gums not sore	
10. Alex. Kennedy. Jan. 9. 27 Samaritan. Syphilis, Jan. 23.	Acid	No change	No change	1010	Gums turgid: teeth factor	Urine clear, pale, and copious: saliva slightly acid.
	Acid	Slight precipitate	No change	1022	Gums not sore.	
11. Elizabeth Gain. Feb. 24. 3 Petersham. Sequela of puerperal convulsions, 26 Dorcas.	Acid	No change	No change	1020	Gums ulcerated: face swollen: upwards of a pint of saliva flowing from the mouth daily	Urine pale, natural quantity: precipitate by heat dispelled by addition of nitric acid: saliva neutral.
12. Harriet Willett. Feb. 24. 26 Dorcas,	Acid	Deposit dissolved: no subsequent change	No change	1016	Gums turgid and sore: glands of neck swelled: teeth loose	Saliva slightly acid.
13. James Hawkes. Feb. 24. Samaritan. Syphilis.	Acid	No change	No change	1017	Gums turgid and ulcerated: teeth loose.	Saliva neutral.
14. Mary Grist. March 2. 13 Lydia. Acute bronchitis.	Acid	No change	No change	1013	Gums turgid: mercurial sores on lips	Urine pale and copious, free from deposit: saliva slightly acid.
15. Elizabeth Allan. March 3. 14 Lydia Jaundice.	Acid	Deposit dissolved	No change	1030	Teeth loose: gums sore and turgid: fœtor	Urine scanty and loaded with deposit: saliva neutral.



From these observations we may safely conclude that mercury does not always produce albuminous urine: and though we cannot say, from these few instances, that it never is a cause of the existence of that principle in the excretion, yet these cases may serve to warn the reader from depending too much upon loose assertions. I have myself observed, that urine containing albumen sometimes becomes freed from that substance by exhibiting mercury to the patient. Dr. Francis, during his late inquiries, met with such a case: and I quote the following from a note I received from him:—

“The other case was one of albuminous urine. The patient was salivated: and whilst under the mercurial influence, the albumen entirely disappeared.”

*Guy's Hospital Reports*, No. xii. 1841.

### *Colouring Principle of the Pink Deposits.*

Dr. Prout has lately examined this point, and comes to the conclusion that the colouring matter is not necessarily composed of murexid, but may be produced by the action of nitric acid or any oxygenating agent on the colouring matters of urine as well as on lithic acid. He believes, however, that nitric acid is the principal cause of such change of colour.

### *Distinction of the more Ordinary Deposits.*

It is frequently desirable to form a correct judgment concerning the nature of the deposits, when visiting patients, and when we have not our laboratory at hand. We cannot always determine their nature from their appearance; for though the lithates are generally darker in colour than the phosphates, still they sometimes approach so nearly in external appearance, that we are scarcely able to distinguish them but by chemical means. I lately was consulted concerning the nature of a deposit which had been regarded as phosphatic, owing to its being of a pure white. It proved to be made up of lithates. When we observe a deposit concerning which we are in doubt, the sedimentary matter can be extemporaneously examined by shaking it up in the urine, and then applying heat to a portion of the turbid fluid; if the sediment dissolves, we may at once conclude that it consists of the alkaline lithates, and, for the most part, of the lithate of ammonia;\* if, on the contrary, the

\* These salts are often found as deposits, in urine which holds albumen in solution. When this is the case, the turbid urine first becomes clear on the application of heat, but afterwards an opaqueness is produced by the coagulation of the albuminous matter.

action of heat fails to render the urine clear, we may be pretty sure that we operate on phosphates, or organic matter in the form of pus or mucus. These may easily be distinguished, since the phosphates are at once dissolved on the addition of hydrochloric acid, whereas the latter substances resist that solvent.

### *Deposits of Matters accidental to the Urine.*

The deposits which have been observed to occur owing to the presence of ingesta in the urine are composed of lime united to the citric, tartaric, and malic acids.

These salts are all reduced to carbonates at a red heat.

Citrate of lime is to be distinguished by the following examination:—

When boiled with a solution of carbonate of potash, a carbonate of lime is deposited, and the citric acid forms citrate of potash with the alkali present.

This alkaline citrate is precipitated by neutral nitrate of lead, and the precipitate collected on a filter. This is known to be citrate of lead from the fact of its being soluble in a solution of caustic ammonia.

Tartrate of lime is known from the characteristic odour of tartaric acid which it evolves when subjected to a charring heat; this test distinguishes the tartrates very completely.

Malate of lime, like the citrate, forms an alkaline salt when boiled with a solution of carbonate of potash; but the precipitate in neutral nitrate of lead produced by this solution is distinguished from that formed by the citrate of potash, in not being soluble in ammonia, but being very freely dissolved by boiling water, and crystallising as the water cools in fine needle-shaped crystals.

### *Diabetes.*

Dr. Henry has constructed the following table, by which we are enabled to determine the proportion of solid extract contained in any quantity of diabetic urine, simply by ascertaining its specific gravity. In the experiments which afforded these results a steam bath was used, and the heat continued until the extract ceased to lose weight.

Specific Gravity. compared with 1000 parts of Water at 60°.	Quantity of solid Extract in a Wine Pint.	Quantity of solid Ex- tract in a Wine Pint, in Ounces, &c.
		oz. dr. scr. grs.
1020	382.4	0 6 1 2
1021	401.6	0 6 2 1
1022	420.8	0 7 0 0
1023	440.0	0 7 1 0
1024	459.2	0 7 1 19
1025	478.4	0 7 2 18
1026	497.6	1 0 0 17
1027	516.8	1 0 1 16
1028	536.0	1 0 2 16
1029	555.2	1 1 0 15
1030	574.4	1 1 1 14
1031	593.6	1 1 2 13
1032	612.8	1 2 0 12
1033	632.0	1 2 1 12
1034	651.2	1 2 2 11
1035	670.4	1 3 0 10
1036	689.6	1 3 1 9
1037	708.8	1 3 2 8
1038	728.0	1 4 0 8
1039	747.2	1 4 1 7
1040	766.4	1 4 2 6
1041	785.6	1 5 0 5
1042	804.8	1 5 1 4
1043	824.0	1 5 2 3
1044	843.2	1 6 0 3
1045	862.4	1 6 1 2
1046	881.6	1 6 2 1
1047	900.8	1 7 0 0
1048	920.0	1 7 1 0
1049	939.2	1 7 1 19
1050	958.4	1 7 2 18

The quantity of solid matter voided by diabetic patients is thus to be ascertained without the delay of evaporation. I have had occasion to test the correctness of this table, and can recommend it as calculated to afford most satisfactory results.

#### *Torulæ in Diabetic Urine.*

This fungoid vegetable growth, which is delineated on the plate fig. 15., is characteristic of the existence of fermentation, and its presence may be regarded as a very correct microscopic test of the presence of sugar.

#### *Urine containing the Principles of Milk.—Kiestein.*

There is a substance of a caseous character which has been called kiestein, and gravidine, occasionally found in the urine of women during gestation. I have had several opportunities

of examining this, and believe it to be the caseous matter of milk altered by passing through the kidney. In several cases of advanced pregnancy I was enabled to detect the presence of milk globules in such urine, and that too in considerable numbers, so as to leave no doubt as to the real origin of the so-called kiestein.

### *Fatty or Chylous Urine.*

I lately had an opportunity of examining a specimen of chylous, or chylo-serous urine, and being at the time engaged in the microscopical and chemical examination of chyle, was enabled to determine the existence of chyle in the excretion satisfactorily to my own mind. The microscopical appearances were such, indeed, as to leave but little doubt that in this form of disease the chyle passes through the kidney. The ordinary chyle granule and globule could be easily detected with the fatty globules intermixed. This kind of urine occasionally deposits a coagulum. The specimen I examined, however, remained unaltered by rest, and had quite the appearance of milk. The specific gravity was 1.021, and it was slightly acid, and remained so for several days. Agitated with ether, it became transparent, the ether dissolving out the fatty matter. These fats were soluble with difficulty in alcohol, and did not saponify with caustic potassa. When incinerated they yielded an alkaline ash. The urine, when cleared by ether, proved to contain albumen, being coagulable by heat and nitric acid.



A GUIDE  
TO THE  
EXAMINATION OF THE URINE  
IN  
HEALTH AND DISEASE,  
FOR  
THE USE OF STUDENTS.

BY

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PHILADELPHIA:  
LEA & BLANCHARD.

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1848





## P R E F A C E.

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THE great impulse that has lately been given to the study of Chemical Pathology has thrown considerable light on many obscure subjects, and effected the solution of various difficult, and hitherto uncomprehended problems. Yet, however important the knowledge thus gained may be, there still remains a great deal to be obtained.

The names of Prout, Bird, Bright, Willis, Percy, Day, Jones, &c., in our own country, and of Berzelius, Liebig, Lecanu, Rayer, Becquerel, Simon, and Lehmann, on the Continent, will ever be remembered by those interested in chemico-pathological investigations, and need only to be mentioned to bring others into this daily increasing field of interesting research.

The urinary secretion is the chief, and at the same time, the most important subject of attention in this branch of science. I have, therefore, endeavoured in the following pages, to give a clear as well as correct description of its composition, both in Health and Disease, and of the various modes of detecting its several normal and abnormal ingredients, with a view to present the Student with a Manual or Pocket Companion that may be useful to him while

prosecuting his Hospital Studies. I have strenuously avoided all discussion, preferring to confine myself simply to the narration of such facts, relative to this very important fluid, as it will then be necessary for him to be possessed of, leaving him to refer to other and more elaborate treatises for more detailed information on urinary diseases. Should I succeed in my object, my labour will be fully repaid by the satisfaction, the knowledge of having done so will be to me.

19, LANGHAM PLACE,

*September, 1847.*

## CHAPTER I.

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1. Two very important actions are continually taking place in the body. They are, *First*, the Destruction or Metamorphosis of the different tissues of which it is composed; and, *Secondly*, the Deposit of fresh materials for their nutrition and repair. Both are admirably effected by the blood, a fluid which takes up the different decomposed and waste matters, and carries to every part its requisite nutritive materials; the former act constituting the second or destructive stage of the secondary assimilating process of Dr. Prout, or in the words of Professor Liebig, the metamorphosis of the tissues, and the latter the primary or formative stage of the same process. In order, therefore, that the blood may be fitted for its purposes, it is evident that fresh blood must be continually formed in order to make up for the loss it sustains, and that it requires to be continually purified. This we find to be accomplished by digestion and respiration, the one separating and rearranging the nutritive matters of our food, the other, through the influence of the atmosphere, converting them into blood; and lastly, by the various secreting and excreting organs which remove from it the various matters with which it becomes impregnated during the destructive processes, some of these being perfectly effete or excrementitious, answering no further purpose in the œconomy, but which, if retained in the system, produce very serious, and even fatal consequences.

The excreting organs are of two kinds; *first* those which separate from the blood, its superabundant carbon and hydrogen, namely, the liver, the lungs, and the skin; the first in the shape of bile, and the two last as carbonic acid and water; and, *secondly*, those which remove from it its highly azotised compounds, such as the urea and lithic acid,

namely, the kidneys. To the latter, and to the skin, too much attention cannot be paid, as it is upon the due and proper performance of their respective functions that our health may be said in a great measure to depend. In fact, how frequently we are called to cases which have entirely arisen either from the suppression, or imperfect excretion of the perspiration or of the urine; and was it not for the wise provisions of nature (which we can but admire) in enabling one excreting organ to antagonise, or, in other words, to compensate for, the deficient action of another, we should, considering the great and frequent changes to which these two excretions are liable, both as to quantity and quality, from various and constantly occurring causes, be continually the subjects of disease.

It will be seen, therefore, that the relations or sympathies, if I may so term them, that exist between the different excreting organs, are of the utmost importance in preventing the imperfect performance of their respective functions, from frequently giving rise to some morbid condition of the system. Thus, when the functions of the skin are impeded those of the kidneys are increased, and *vice versâ*, and when the powers of respiration are diminished they are replaced by an increased activity of the liver; and lastly, when the latter is sluggish, the kidneys make up for the deficiency, by excreting a larger quantity of carbonised matter. Unfortunately, however, this compensating effect does not always take place; hence it is that when an organ has been previously diseased and consequently weakened and rendered susceptible of, or predisposed to, further morbid action, it is almost sure to suffer, when, from any cause, it is called upon for increased exertion. Numerous examples of this fact are presented to us by the kidneys, than which, there is, I should say, no organ more susceptible of derangement, or whose secretion is subject to so much variation, both in health and disease, and from the slightest causes; and this cannot be wondered at when we consider that these organs are the emunctories by which not only a considerable portion of the waste matter that is of no further use to the system is got rid of, but also large quantities of fluid with which the blood becomes overcharged after copious draughts of liquid, and various other matters which have

entered the circulation after a repast. It is evidently therefore very essential that we should be thoroughly acquainted with the normal composition and character of the urinary excretion, and at the same time able, not only to discover any deviation from the healthy standard, but also correctly to ascertain in what that deviation consists. And this has of late years become the more necessary in consequence of the valuable researches, on this subject, of Prout, Becquerel, Bird, Liebig, Simon, and others, who have thus rendered the study of urinary diseases extremely interesting and useful. In fact, as Dr. Bird has remarked "Med. Gaz. for Feb. 10, 1843:" "the examination of the urine in disease is now regarded as one of the most important aids in diagnosis, and which it would be alike injurious to the welfare of the patient, as to the credit and reputation of the practitioner to avoid."

I propose then, *first*, to speak of the properties and composition of healthy urine and the various modifications it is liable to undergo, both in health and disease, and afterwards to describe the mode of analysing it.



CHAPTER II.

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2. The urine is a fluid composed of certain effete, animal, and saline matters, which have been separated from the blood by the kidneys.\* In health, immediately on being passed, it is in adults, transparent, of an amber colour, something like that of Sherry wine, and of a temperature varying between 95 degs. and 100 degs. Farhn. It has a bitter, disagreeable, saltish taste, which is more or less marked according as the urine is more or less concentrated; an acid reaction on litmus, and a peculiar somewhat aromatic odour, which is said to resemble that of violets. This on cooling goes off, and becomes replaced by one, *sui-generis*, to which the term *urinous* has been applied; this also disappears in a few days, but may be restored by heating the fluid, and is succeeded by one resembling sour milk, and lastly by one of fetid ammoniac-alkaline character. The urine of infants on the contrary, is almost colourless and without smell when passed, but evolves an odour on standing resembling that of veal broth. It has scarcely any reaction on test paper, and is very low in density.

3. The *odour*, however, is liable to be greatly altered by certain articles of food, such as asparagus, onions, garlic, &c., and by some kinds of medicine, as turpentine, copaiba, assafoetida, and the essential oil of the juniper berry, each of which imparts to the urine its peculiar characteristic fragrant principles. It is likewise considerably influenced by disease. Thus it is particularly strong in all cases of fever and inflammation, for instance, and slight or

\* The urine was formerly supposed to be secreted from arterial blood. Mr. Bowman has, however, attempted to prove in a paper, published in the Philosophical Transactions for 1842; also Med. Gaz. vol. xxx, "On the Structure and use of the Malpighian bodies." that it is like the bile separated from venous blood.

even entirely wanting in those of anæmia and hysteria; while in diabetes immediately the urine is voided, it resembles that of whey, and subsequently, when fermentation commences, is of an alcoholic nature.

4. The *colour* also varies and depends in a great measure on the degree of concentration of the secretion. Hence it is generally darker in summer than in winter, owing to the solid contents of the urine being relatively increased at this season. It is, generally speaking, somewhat darker in men than in women, owing, I fancy, in a great measure, to their more active exertion, causing an increase of the cutaneous exhalation, and thereby diminishing the amount of fluid in the urine. It is also greatly modified by particular states of the system, by certain articles of food, and by some medicines. Thus, it is deep in febrile affections, pale in nervous diseases, anæmia, &c., and yellowish or of a dirty brown in bilious disorders. It is of a more or less deep brown in proportion to the animal diet of the person, and when chimaphila or the pareira brava have been administered; reddish after the ingestion of beet-root, the prickly pear (*Cactus Opuntia*;) and hæmatoxylon, and yellowish when rhubarb has been taken. Rayer also states that the urine of an epileptic patient had a light green tint after a few day's use of sulphate of indigo, in doses of from one to three drachms in the course of twenty-four hours; and De Velseu gives an instance of an old man affected with chronic inflammation of the bladder in whom it became of a deep violet colour after the use of lime water mixed with milk.\* Drs. Prout and Simon have also met with cases in which it was of a dark blue owing to the presence of indigo which in all probability had become generated in the system. It is likewise much altered by foreign substances, as blood, pus and bile, the former renders it of a dirty red, brown or black, the second of a dirty yellowish white, and the last of a more or less deep yellow, sometimes approaching to a dark brown, or even black.

5. Dr. Prout is of opinion that the colour of the urine is due to the presence of two colouring principles, one of

\* Quoted in the Med. Gaz. for August 8th, 1845, from *Heller's Archiv.* Heft 1, 1844.

which is closely allied to lithic acid and lithate of ammonia, and gives them their yellow colour, and the other to some modification of the colouring matter of the bile; and he believes both to be intimately connected one with the other from the circumstance that lithic acid and the biliary colouring principle are similarly affected by nitric acid. Simon believed the first to be identical with the yellowish brown matter, viz. the *hæmaphæin* that is extracted from the dried serum of the blood by ether and alcohol.\* Becquerel also supposes the colouring matters of the urine to be composed of two others; one of a greenish and the other of a reddish colour, and he states that the latter generally predominates when the urinary secretion is high coloured and loaded with uric acid and organic matters. This is perfectly in accordance with Dr. Prout's statement. Berzelius has applied the term *halophyle* to the yellow colouring matter of the urine, in consequence of the great difficulty of separating it from the saline principles of the secretion. Heller, on the other hand, has given it the name of *wroxanthin*, which he says "occurs in solution in very small proportion in healthy urine, but is much increased in certain forms of disease."†

6. Some discrepancy of opinion exists respecting the pigment which gives to the urine and its lithic deposits that peculiar rose and purple tint in certain cases of derangement of the portal circulation. Dr. Prout considers it to be the *purpurate of ammonia*, the *murexid* of Liebig. Dr. Bird believes it to be a principle very different to this, and to which he has given the name of *Purpurine*. His reasons for differing from Dr. Prout are founded on the different behaviour of the two substances towards certain reagents; and on the latter being soluble and the former insoluble in alcohol; while M. Rayer thinks it is the *rosacic acid* of Vauquelin. Simon describes a principle closely allied to it under the name of *uroerethrin*; and Heller states that the yellow pigment of the urine, which he has termed *uroxanthin*, "possesses the property of being converted by oxidation, (either spontaneously or artificially,) in two other pig-

\* Simon's Handbuch, b. 1. s. 328.

† Simon's Animal Chemistry, by Day, vol. ii. p. 522.

ments, one of which is of a ruby-red tint, *urrrhodin*," and no doubt identical with the purpurine of Dr. Bird, "while the other is of the colour of ultramarine, (*uroglaucin*." They both "occur in diseases different in most of their characters, but similar in one—the presence of an excess of urea in the blood: thus they are found in Bright's disease, in cholera, and in suppression of urine. Further, when these products occur in considerable quantity, (especially when the blue sediment is spontaneously formed,) there, is always much carbonate of ammonia, and very little urea (perhaps mere traces) in the urine, as is often the case in Bright's disease. Finally, Heller has observed the blue tint developed by nitrate of urea artificially prepared and kept moist, and has likewise produced it by adding nitric acid to an old solution of urea, partially converted into carbonate of ammonia,"\* and hence they are in all probability, together with the uroxanthin, derived from urea.

Scherer states as the results of his experiments that the colouring matter of urine is allied to both that of the blood and bile and he is led to believe that it is formed from the hæmatin of arterial blood, and that its formation is analogous to that of the urea and lithic acid. He states its composition to be as follows:

Carbon	.	.	58.43
Hydrogen	.	.	5.16
Nitrogen	.	.	8.83
Oxygen	.	.	27.58
<hr/>			
			100.00

In those diseases accompanied by an inactive state of the lungs and of the liver, and by rapid metamorphosis of the tissues, the two first elements become remarkably increased. The opinion therefore expressed by Dr. Bird, namely: that an excess of this matter in the urine may be considered as an evidence of the kidneys performing a compensating function for the lungs and liver receives very strong corroboration; and the great similarity that is found to exist between the composition of the normal colouring matter of

\* Simon's Chemistry.

the urine as given above, and that of purpurine, of the bile pigment, and of the urinary colouring matter in jaundice, still more confirms it.

The following are the respective compositions of these principles according to Dr. Bird :—

	Urinary colour- ing matter of jaundice.	Urinary colour- ing matter in or- ganic disease of the liver.	Bile Pigment from urine.
Carbon . . .	60·19	65·76	68·182
Hydrogen . .	6·68	6·01	7·437
Nitrogen . .	} 34·25	} 28·23	{ 7·074
Oxygen . . .			
			{ 17·261

A non-nitrogenized diet has likewise the effect of increasing, although not in equal proportions, the quantity of carbon and hydrogen passed with the urine, even when there is no alteration in the amount of exercise taken or of oxygen absorbed. An excessive secretion of this principle for any length of time, gives rise, according to Scherer, to anæmia and emaciation.

7. The *quantity* of urine passed in twenty-four hours has been differently stated by different authors. Thus, Haller estimated it at 49 ounces; Simon at 45; Bostock and Rye at 40; Venables considered it to average between 40 and 50; Rayer between 21 and 57; Becquerel about 46, and Dr. Prout between 30 and 40 ounces. Becquerel also states that it may range within the limits of health between 28 and 53 ounces. Dr. Prout's estimate will I think on the whole, for this country at least, be found the most correct. It appears to be somewhat less in men than in women, according to Becquerel; although the contrary is stated to be the case by Dumas and Burdach.

8. The quantity, however, is much influenced by various circumstances. It is generally found to be increased in cold and damp weather; by a vegetable diet, and according to Mr. Erichsen,\* during the process of digestion, a short time after its commencement, and by exercise;† by certain

\* Med. Gaz. July 4, 1845.

† Exercise has generally been supposed to diminish the secretion of urine; but I think when we consider that any thing which accele-

medicines, as squills, digitalis, colchicum, and various resinous and saline compounds, particularly the salts of soda, &c., and by the ingestion of large quantities of watery and aërated fluids. In order, however, that liquid potations may have the effect of increasing the quantity of the urinary secretion it is necessary, as Professor Liebig, has proved, that their density should be less than that of the blood, otherwise instead of being absorbed into the circulation they attract water from the blood on the principle of exosmosis, causing the sensation of thirst, and eventually become discharged by the bowels. Hence it follows that to ensure the action of a diuretic salt it should be given in a very diluted state. It is diminished in hot and dry weather: and when the cutaneous and pulmonary exhalation, and the alvine excretions are augmented; and according to Boucharlat by alcoholics. It also varies considerably in certain morbid conditions of the system; thus it is increased in Diabetes, Polydipsia, Hysteria, and other nervous affections, and likewise by fear, mental emotions and grief; and is diminished in cases of fever and inflammation, rheumatism, disease of the liver, and hepatic and cardiac dropsies.

9. The natural *transparency* of healthy urine is liable to be disturbed whenever the proper relative proportions of its constituents are altered, or when it contains some preternatural or foreign matter. Hence it is that urine frequently becomes turbid from the presence of mucus, pus, or blood; from an excess of lithic acid or lithate of ammonia; from the superabundance of the phosphates, or in consequence of the decomposition which the fluid undergoes in disease, or by keeping. Some of these form a kind of scum on the surface of the urine, and constitute what is termed a *pellicle*; others float in it near the surface, and form a *cloud*; while others again become precipitated to the bottom of the containing vessel and give rise to a *sediment*. Dr. Bird has included the whole under the term of urinary deposits, which he has divided, into the four following classes.

rates the circulation must tend to stimulate the secreting organs, we should have been perfectly justified in supposing the contrary, as now proved to be the case by the investigations of Mr. Erichsen.



*Class 1.*—Deposits composed essentially of ingredients formed directly or indirectly from the metamorphosis of tissues, or from the inorganic elements of food capable of assuming a crystalline form.

Uric Acid and Urates.  
Uric Oxides.  
Oxalate of lime.  
Cystine.

*Class 2.*—Deposits composed of ingredients of inorganic origin ; including :—

Phosphate of lime.  
Ammonio-phosphate of magnesia.  
Carbonate of lime.  
Silicic Acid.

*Class 3.*—Highly coloured deposits (black or blue) of doubtful origin :—

Cyanourine.  
Melanourine.  
Indigo.  
Prussian Blue.

*Class 4.*—Deposits consisting of non-crystalline organic products ; including :—

A. *Organised.*  
Blood.  
Pus.  
Mucus.  
Organic Globules.  
Epithelium.  
Spermatozoa.  
Torulæ.  
Vibriones.  
B. *Non-Organised.*  
Milk.  
Fatty Matter.  
Stearolith.

10. Its *consistence* varies with its density, and with the presence of foreign matters. Thus the greater the specific gravity, the more consistent the urine, and *vice versâ*. It is also increased by mucus, blood, pus, albumen, sugar, and oxalate of lime, and by an excess of lithic acid.

11. The *specific gravity* is subject to much variation. Like the consistence it depends on the degree of concentration of the urine, and on the presence of foreign matters, and has been stated by different authors to oscillate between 1.010 and 1.020. Thus M. Becquerel gives 1.018 as the mean in men, and 1.015 in women. Simon places the average at 1.012.6; Lecanu at between 1.020 and 1.030; Dumas at between 1.015 and 1.030, and Aldridge at 1.015; while Dr. Prout thinks 1.020 will be a more correct average for this country.

12. The specific gravity however differs, according to the specimen of urine examined, whether it be that passed on rising in the morning, or that excreted after copious liquid potations, or that voided after a meal. Hence, and from the particular source from which each is derived, the division of the urine into three different kinds. 1. The URINA SANGUINIS, the urine of the blood, or morning urine. 2. The URINA POTUS, and 3. The URINA CHYLI, or of digestion. The first which may be considered as the urine *par excellence*, varies in density from 1015 to 1025; the second being oftentimes excessively dilute is of extremely low weight, and in some cases indeed little heavier than distilled water: while of the third, or the urine from food, the specific gravity is generally considerably increased both in health and disease, and may be said to range between 1020 and 1030.

13. Dr. Schweig states that there is a constant rate of increase and decrease in the density of the urine throughout the day, and that, *cæteris paribus*, it varies in the morning from 1.017 to 1.022; in the afternoon from 1.023 to 1.028; in the evening from 1.019 to 1.028; and in the night from 1.022 to 1.025. Moreover, that the specific gravity of the night urine passes through certain limits in a cycle of six days, attaining a minimum twice in that period. The following table represents the average density of twenty such periods.

Nights of the Cycle.						Density of the Urine.
1	.	.	.	.	.	1.022
2	.	.	.	.	.	1.017
3	.	.	.	.	.	1.019
4	.	.	.	.	.	1.020
5	.	.	.	.	.	1.019
6	.	.	.	.	.	1.017

From this it appears that the specific gravity is higher on the first night and lower on the second and sixth than on any other. According to Dr Schweig five of these cycles occur in each lunar revolution, the night previous to the new moon being counted as the second day of one of the cycles.\*

14. In consequence therefore of this variation in the density of the urine at different times of the day, it is necessary, in order to avoid error, and for the sake of perfect accuracy, that three things should be attended to. The *first* is to collect the whole of the urine evacuated in twenty-four hours, otherwise we may be led to suppose from the low density of a given specimen of urine, that the amount of solids excreted in twenty-four hours is much below the healthy standard, whereas it may not only not be at all diminished, but on the contrary, somewhat increased. In fact so important is this in disease that were we to neglect it we should be frequently liable to error, as an excess of the solid constituents of the urine, relatively to the quantity of water it contains may be present in a particular sample voided at a certain time, when the amount excreted in the twenty-four hours does not exceed, or perhaps is not so great as that in health, and *vice versâ*. The *second* is to ascertain the quantity of its watery portion; for in proportion as this is increased or diminished, so will the density, *cæteris paribus*, be decreased or augmented. Consequently if the quantity of urine passed during the day be not greatly above or below the normal standard and its specific gravity is very low, we may conclude that the proportion of its solid ingredients has considerably diminished; but, if on the other hand, we find the amount of urine is much greater than natural, then we may attribute the diminution in den-

\* See Dr. Bird's work on Urinary deposits, Second Edition, page 32.

sity to the proper relative proportions that normally exist between the solid and fluid portions of the urine having become destroyed. And we must not, as I have just now alluded to, suppose that the decrease of specific gravity from this cause is the criterion of the urine of a given time containing a less amount of solid matter than it should do, as the very reverse will, in all probability, be found to be the case. Again if the amount excreted in the twenty-four hours be normal or even greatly augmented, and the specific gravity high, we may confidently assert that the alteration is due either to an excess of urea or to the presence of some extraneous matter such as sugar. The *third* is to examine its temperature: for Simon found that urine of specific gravity, 1020.75, at 59 degs. Farh., became reduced to 1019.85 when the temperature was increased to 64 degs. and increased to 1021.46 when it was lowered to 53 degs. Farh.

15. It often happens that we are unable to collect the whole of the twenty-four hours urine, either from the patient being ignorant of its importance, and in consequence unwilling to strictly attend to the requisite precautions, or from his inability to suppress the evacuation of the bladder when unloading the bowels. In this case we must be content with the average density presented by the urine that is passed after a night's rest, and by that excreted after digestion on going to bed, which will be generally sufficiently accurate for all practical purposes.

16. The urine in some cases possesses certain optical properties which have been taken advantage of as a means of diagnosis. They have been employed principally in the detection of saccharine diabetes, in which disease, as also in albuminuria, the urine has the power of producing the circular polarization of a polarized beam of light. The obstacles and difficulties, however, attending this method, are such as will, in all probability, prevent its ever coming into general use,\* notwithstanding all that has been said in its favour by Bouchardat and Biot; and moreover Dr. Leeson has proved that it is by no means to be depended on.†

17. Various analyses have been given of the urine. Ac-

\* See a translation of Bell on Diabetes by the author, page 17.

† See part vii. of the Memoirs of the Chemical Society.

cording to Berzelius 1000 parts consist of 933 of water and 67 of solid ingredients, 30.10 of which represent urea and 1 uric acid; the remaining 35.90 being constituted by 17.14 of organic matters, such as the lactic acid, the lactate of ammonia and colouring principles, &c., by 18.41 of alkaline and earthy salts, as the sulphates of potash and soda, the phosphates of soda, ammonia, lime and magnesia, the muriates of soda and ammonia, and a trace of fluete of lime, and by 0.32 of vesical mucus, and .03 of silex.

It is much to be regretted, however, that this distinguished chemist has not informed us either of the kind or the density of the urine he examined; but we have every reason to believe, from the large proportion of solids it contained, that it was a specimen much above the normal standard, and therefore cannot be considered as a type, with which all calculations and investigations both in health and disease are to be compared.

18. Becquerel's analysis, as modified and arranged for this country by Dr. Prout, has been generally considered as more approaching the truth, and is given in the following table.

TABLE I.

*Which shows the average Normal Quantity, Specific Gravity, and Composition of the Urine in this country.*

Quantity, Specific Gravity, and Composition of the Urine.		Urine in 24 hours.	Composition of 1000 parts.	
Quantity of Urine . . . . .		35 fld. oz.	1000	
Specific Gravity . . . . .		1.020		
General Composition	{ Water . . . . .	14807 grs.	967	
	{ Solid Matters . . . . .	505	33	
Details of Analysis.	Water . . . . .	14807 grs.	967.	
	Urea . . . . .	226.802	14.230	
	Lithic Acid . . . . .	7.190	.468	
	Organic matters inseparable from each other .	{ Lactic Acid . . . . .	146.467	10.167
		{ Lactate Ammonia. . . . .		
		{ Colouring matters . . . . .		
		{ Extractive matters . . . . .		
	Fixed salts indecomposable at a red heat	{ Muriate Ammonia . . . . .	a 124.541 b	8.135
		{ Chlorides { Lime . . . . .		
		{ Phosphates { Soda . . . . .		
		{ tes { Potash . . . . .		
		{ Sulphates { Magnesia . . . . .		
			15312.000	1000.000

Composition of the entire quality of Fixed Salts voided in 24 hours; and in a 1000 parts of urine.

(a) Fixed Salts voided in 24 hours.		(b) Fixed Salts in 1000 parts.	
Chlorine . . . . .	9.04	Chlorine . . . . .	.591
Sulphuric Acid . . . .	15.39	Sulphuric Acid . . . .	1.006
Phosphoric Acid . . . .	5.72	Phosphoric Acid . . . .	.373
Potash . . . . .	23.40	Potash . . . . .	1.529
Soda { . . . . .	70.99	Soda { . . . . .	4.638
Lime { . . . . .		Lime { . . . . .	
Magnesia { . . . . .		Magnesia { . . . . .	
	124.54		8.137

Here the solid matters are represented in the proportion of only 33 instead of 67 in 1000 parts of urine, the specific gravity being 1020; an amount which will be seen to but little exceed the proportion of urea, and to be not quite one half that of the whole of the solids stated by Berzelius to be present in the same quantity.

19. This amount however appears to be much too small from the researches of Dr. Day,\* who has proved the formula  $\Delta \times 2.33$  of Dr. Christison† to be more accurate than that of either Dr. Henry or Dr. Becquerel, which are  $\Delta \times 2.58$  and  $\Delta \times 1.65$  respectively; the average error from using it being only .47 in 1000 parts, while the mean error of Dr. Henry's formula is 7.71 and that of Dr. Becquerel, 21.92.

The following table has therefore been constructed for the purpose of showing the *probable* composition of the urine according to Dr. Christison's formula.

\* Lancet vol. i. 1844, p. 373,

† Library of Medicine vol. iv. p. 248.



TABLE II.

Quantity, Specific Gravity and composition of the Urine.		Urine in 24 hours.	Composition of 1000 parts.
Quantity of Urine . . . . .		35 fl. oz.	1.000
Specific Gravity . . . . .		1.020	
Urea . . . . .		304.550	19.889
Uric Acid . . . . .		9.999	0.653
Peculiar Azotised principle (Pettenkofer)		76.600	5.000
Hippuric Acid . . . . .		7.365	0.481
Organic matters inseparable from each other.	Colouring matters . .	140.929	9.206
	Extractive matters . .		
	Muriate Ammonia . .		
Fixed Salts indecomposable at a red heat .	Chlorides { Lime .	a 174.118	b 11.371
	Phosphates { Soda .		
	Potash .		
	Sulphates { Magnesia }		
Total amount of Solids . . . . .		713.561	46.600
Quantity of Water . . . . .		14598.939	953.400
Total amount of Urine . . . . .		15312.500	1.000.000

Composition of the entire quantity of Fixed Salts voided in 24 hours; and in 1000 parts of urine.

(a) Fixed Salts voided in 24 hours.		(b) Fixed Salts in 100 parts.	
Chlorine . . . . .	12.64	Chlorine . . . . .	0.826
Sulphuric Acid . . . .	21.52	Sulphuric Acid . . . .	1.406
Phosphoric Acid . . . .	7.97	Phosphoric Acid . . . .	0.521
Potash . . . . .	32.72	Potash . . . . .	2.137
Soda	99.25	Soda	6.482
Lime }		Lime }	
Magnesia }		Magnesia }	
	174.10		11.372

20. Lehmann states the average amount of solid ingredients to be as follows:

After a mixed Diet . . . . .	1.047.000
“ an Animal Diet . . . . .	1.349.898
“ a Vegetable Diet . . . . .	914.541
“ a non-nitrogenous diet . . . . .	643.455

and Lecanu informs us that the composition of the urine will be found to vary but little in the same individual at stated times, but that very great differences will be found in the secretion of different persons.

21. Its solid contents however generally become diminished in debilitated states of the system, and when the blood corpuscles are decreased in number, although in land scurvy Heller detected a slight increase. The proportion in this disease was in one case 50.72, the specific gravity being 1.021. M. Chambert, in a memoir presented to the Academie des Sciences, on the 2d June, 1845, deduces as the results of his investigations. 1st, That the urine of the food contains more saline matter than that of the blood; 2d. That the inorganic principles are in a direct ratio with the quantity of salts introduced with the food. 3d. That the saline ingredients are more abundant in the urine of the blood in proportion as they exist in larger quantity in that of digestion. 4th. That there is no relation between the saline matter and the specific gravity of the urine, or between them and the organic principles.

22. The ingredients held in solution in healthy urine may with Dr. Bird be arranged under the three following heads.

### I. ORGANIC PRODUCTS.

- |  |   |
|--|---|
| 1st. Ingredients characteristic of the secretion produced by the destructive assimilation of tissues, and separated from the blood by the kidneys. | } Urea, Uric acid, colouring and odorous principles, and a crystalline nitrogenised body. |
| 2d. Ingredients developed principally from the food during the process of assimilation   |   |
|  | } Hippuric acid, lactic acid? and accidental constituents.                                |

### II. SALINE PRODUCTS.

- |  |                                   |
|--|-----------------------------------|
| 3d. Saline combinations separated from the blood, and chiefly derived from the food.       | } Phosphates, Chloride of Sodium. |
| 4th. Saline combinations chiefly generated during the process of destructive assimilation. |                                   |
|  | } Sulphates.                      |

## III. INGREDIENTS DERIVED FROM THE URINARY PASSAGES.

5th. Mucus of the bladder.

6th. Debris of epithelium.

Under the *first* head are placed those elements which are destined to be secreted by the kidneys from the blood, and to the presence of which in the urine, the characteristic properties of the latter are due. Under the *second* are classed several saline compounds most of which are present in the various other secretions, the sulphates alone appearing to be peculiar to the urine; while under the *third* head we find certain matters common to all secretions passing over mucous membranes.

I. *Organic Products.*

23. *Urea* enters more largely than any other substance into the composition of the urine. It is described by Dr. Prout as assuming the form of four sided prismatic, colourless, transparent crystals, of a pearly lustre, which leave a sense of coldness on the tongue like nitre. It has a faint and peculiar, but *not urinous*, smell, is neither acid, nor alkaline; undergoes no change on exposure to the air, except in very damp weather, when it slightly deliquesces, but does not seem to be decomposed. Pulverized and mixed with salts containing water of crystallization it separates the latter, and the mass becomes either soft or perfectly liquid according to the quantity of water contained in the saline substance. It also has a singular effect on the crystallization of particular salts. Thus it converts the natural cubical form of *chloride of sodium* (common salt) into the octahedral, and the characteristic octahedral shape of *hydrochlorate of ammonia* into the cuboid. Its specific gravity is 1.35; is soluble in its own weight in cold and any proportion of hot water; and in four and a half parts of cold, and about two parts of boiling alcohol, from which latter it separates in a delicately crystallized form on cooling.\* *Urea* has no neutralizing power but combines with acids, especially the nitric and the oxalic.

24. The nitrate of urea is represented by Drs. Prout and Lehmann as being composed according to their analyses of

one equivalent of nitric acid and one equiv. of urea. Regnault, and more lately Heintz, on the other hand, have found it to contain one equiv. of water in addition. The following is the composition of 100 parts of this salt as given by different chemists.

	<i>Prout.</i>	<i>Lecanu.</i>	<i>Marchand.</i>
Nitric Acid . . . . .	47.375	- 47.00	- 66.11
Urea . . . . .	52.625	- 53.00	- 33.89
	<hr/>	<hr/>	<hr/>
	100.000	- 100.00	- 100.00

	<i>Regnault &amp; Becquerel.</i>	<i>Heintz.</i>
Nitric Acid . . . . .	43.781	- 44.14
Urea . . . . .	48.938	- 48.86
Water . . . . .	7.281	- 7.00
	<hr/>	<hr/>
	100.000	- 100.000

Oxalate of urea contains in 100 parts according to Berzelius,

Oxalic Acid . . . . .	37.436
Urea . . . . .	62.564
	<hr/>
	100.000

25. In the opinion of M.M. Cap and Henry, urea exists in the urine, partly in combination with lactic acid. This however is doubted by Pelouze, Lecanu, Liebig, and Dumas; the latter indeed seems more inclined to believe that it is present in a free state, but nevertheless believes it possible that it may exist in combination with sal ammoniac and chloride of sodium\* to a greater or less extent.

26. Dr. Prout from his analysis gives the composition of urea as follows:

Carbon . . . . .	19.99
Hydrogen . . . . .	6.65
Nitrogen . . . . .	46.65
Oxygen . . . . .	26.63†

\* Med. Times, vol. xvi. p. 29.

† Thomson's Annals, vol. xi. p. 353

Wöhler and Liebig represent it as being composed of

Carbon	.	.	.	20.02
Hydrogen	.	.	.	6.71
Nitrogen	.	.	.	46.73
Oxygen	.	.	.	26.54*

27. Its formula is  $C_2, O_2, H_4, N_2$ . Hence it will be seen to represent either one atom of Cyanogen, two of water, and one of Amidogen thus:

C.	N.	H.	O.	
2	+	1		= one atom cyanogen.
		2	+	2 = two atoms water.
	1	+	2	= one atom amidogen.
<hr/>				
2	+	2	+	4 + 2 = one atom urea.

Or two atoms of carbonic oxide and two of amidogen thus:

C.	N.	H.	O.	
2			2	= two atoms carbonic oxide.
	2	+	4	= two atoms amidogen.
<hr/>				
2	+	2	+	4 + 2 = one atom urea.

28. Its formula also readily explains the formation of the cyanate and carbonate of ammonia, and oxalic acid in the urine. For by *abstracting one* equivalent of water from one of urea we have the composition of one atom of cyanate of ammonia.

	C.	N.	H.	O.	
	2	+	2	+	4 + 2 = one atom urea.
minus			1	+	1 = one atom water.
<hr/>					
gives	2	+	2	+	3 + 1 = one atom cyanate ammonia.
<hr/>					

and if we *add two* equivalents of water to one of urea we

\* Poggend. Ann., xx. p. 375.

have the composition either of two atoms of carbonate of ammonia as follows:

	C.	N.	H.	O.				
	2	+	2	+	4	+	2	= one atom urea.
plus.					2	+	2	= two atoms water
<hr style="border: none; border-top: 1px solid black; margin: 5px 0;"/>								
gives.	2	+	2	+	6	+	4	which is equal to
<hr style="border: none; border-top: 1px solid black; margin: 5px 0;"/>								
	2						4	= two atoms carbonic acid
			2	+	6			= two atoms ammonia.
<hr style="border: none; border-top: 1px solid black; margin: 5px 0;"/>								
	2	+	2	+	6	+	4	
<hr style="border: none; border-top: 1px solid black; margin: 5px 0;"/>								

Or of one equivalent of oxalic acid, two of ammonia and one of oxygen, thus:

	C.	N.	H.	O.				
	2	+	2	+	4	+	2	= one atom urea.
plus					2	+	2	= two atoms water.
<hr style="border: none; border-top: 1px solid black; margin: 5px 0;"/>								
gives.	2	+	2	+	6	+	4	which is equal to
<hr style="border: none; border-top: 1px solid black; margin: 5px 0;"/>								
	2						3	= one atom of oxalic acid.
			2	+	6			= two atoms ammonia.
							1	one atom oxygen.
<hr style="border: none; border-top: 1px solid black; margin: 5px 0;"/>								
	2	+	2	+	6	+	4	
<hr style="border: none; border-top: 1px solid black; margin: 5px 0;"/>								

Another probable source of the oxalic acid occasionally met with in the urine will be alluded to under the head of uric acid, (32.) The above is Dr. Bird's hypothesis.\*

29. The conversion of the urea into carbonate of ammonia occurs much more rapidly, generally speaking, in warm weather than in cold; and also when the urine contains a good deal of mucus, which, in that case, by undergoing putrefaction may, according to Dumas, act as a ferment. But in order that putrefaction may take place in the healthy secretion it is essential, as proved by the researches

\* Guy's Hosp. Reports for April, 1842.



of Guy-Lussac, that the atmospheric air, or rather the oxygen contained in it, should have free access to the fluid. For it appears that so long as this is excluded from the air by being confined in well stoppered bottles, its odour, transparency, and natural acid reaction remain unaltered, uric acid being alone deposited; whereas if placed in contact with the air, the oxygen of the latter becomes absorbed and may, by combining with the nitrogenous extractive principles of the urine, in the opinion of M. Dumas and Dr. Aldridge, and with the colouring matter as believed by Liebig, probably transform these substances into nitrogenized ferments which are thrown down in an insoluble state, and the urea into carbonate of ammonia, which, by rendering the urine alkaline, causes the phosphate of lime and triple phosphate to be also precipitated. Still it not unfrequently happens, however, that this change, namely the conversion of urea into carbonate of ammonia, takes place in the bladder, into which no air is ever admitted; and I have no doubt, even in some cases, although it has been stated to the contrary, previous to secretion, the urine being under those circumstances passed in an alkaline condition. I shall have occasion to refer more particularly to this important fact bye and bye.

30. Moreover it would appear from the late investigations of Drs. Sunderland and Rigby, that this metamorphosis is very prone to take place during certain forms of mental derangement. Thus they found that in dementia the urine effervesced on the addition of an acid in 34.37 per cent; in melancholia 30, and in mania, 16.67 per cent; and that in the first mentioned affection, the urine when passed in an acid condition, has a tendency to very speedily become alkaline.\* Dr. Erlenmeyer however states that the urine of maniacs, which he says is generally pale and deficient in solid constituents, particularly lithic acid and its compounds, is more disposed to be alkaline than that of melancholics; and he considers that in proportion as there is a greater disposition in the latter class of cases for the urine to assume an alkaline reaction, without there being any accompanying organic affection either of the brain or

\* Med. Gaz. vol. 36. p. p. 235, 229.

spinal marrow, the more liable are they to become worse, and pass into mania.\*

31. According to Berzelius's analysis we find urea to exist in the urine in the proportion of 30.10 to 1000, but Becquerel, who has made several apparently very careful examinations of the urinary excretion, considers this much too great. He states it to be between 10 and 14 parts only in 1000 and the quantity passed in 24 hours to vary between 15 and 18 grammes,† or 231.570 and 277.884 grains; the minimum specific gravity being 1015 and the maximum 1018.

32. M. Lecanu found the proportion to be much greater than this in adult men and women and less in old men and children. The following shows the results he obtained from 120 analyses.

	Min.	Max.	Mean.
In adult men . . . . .	357.466	510.303	433.884
In adult women . . . . .	154.237	437.003	295.112
In old men (84 to 86 years) . . . .	61.072	189.312	125.202
In Children of about 8 years . . . .	161.759	254.171	207.965
In Children of about 4 years . . . .	57.274	81.821	69.548

Still the amount excreted by the same individual in a given space of time was always much the same. It is not present however in the urine of children at the breast according to Lecanu, Rayer, Guibourt and others.

33. The quantity moreover appears from the experiments of M. Lehmann on himself to be considerably modified by different kinds of diet; thus, from his urine of 24 hours he obtained,

After a non-nitrogenous diet . . . .	237.909 grains.
After a vegetable diet . . . . .	347.061 „
After an animal diet . . . . .	821.270 „
And after a mixed diet . . . . .	501.704 „

Bouchardat also states it to be diminished by alcoholics, and Lehmann, Simon, and Percy have found it to be augmented by violent bodily exertion.

\* Med. Times, vol. xvi. p. 237.

† A Gramme is equal to about 15.438 grs.

34. It is also much affected by disease, but an absolute excess in a given time is, according to Becquerel, of rare occurrence ; the general rule being an absolute diminution. According to the researches of Mr. Stuart Cooper, there appears to be no proportionate diminution between this and the other elements contained in the urine ; for he frequently found the urea to be considerably reduced in quantity and yet no very great decrease in the amount of the other organic and inorganic matters. It is very abundant in plethoric states of the body, and remarkably scanty in anæmia; its quantity apparently coinciding in a direct ratio with the globules in the blood, for whatever increases or diminishes the latter, tends to augment the former (*Andral.*)\* In cases of fever, rheumatism, and other inflammatory diseases, &c. the urine in twenty-four hours also contains a less amount of urea, although a given specimen may indicate an excess. This is owing to the scantiness of the urine. It is likewise diminished in cirrhosis and hepatic dropsy, in various chronic and neuralgic affections, and in albuminuria or granular degeneration of the kidneys, while in diabetes it was thought that the saccharine matter had taken its place. This has however been proved by more recent analysis not to be the case. In fact, Mr. McGregor was led to believe that patients labouring under this disease excreted “in twenty-four hours a much greater quantity of urea, than a person in health does in the same space of time,”† although a given specimen of diabetic urine contains a less proportion than the same quantity of the healthy secretion. Drs. Kane and Bouchardat consider the quantity to be the same as in health, while Drs. Prout and Henry estimate it at something less. Judging, however from the animal diet that must necessarily be employed in this disease we should have been inclined to believe that the urea would be rather in excess than otherwise. It is also stated by Bouchardat to be considerably diminished in a disease of which one of the principal features is the presence of a large quantity of hippuric acid in the urine, and hence termed by him hippuria.‡ The greatest decrease observed

\* *Med. Times*, vol. xv. p. 285.

† *Bell's Essay on Diabetes*, p. 21.

‡ *Annuaire de Thérapeutique* for 1842, p. 285.

by Becquerel in twenty-four hours was in those cases in which there was great debility accompanied by slight febrile action; the average quantity here being only 75.924. It however frequently happens that in a given specimen of urine the amount of urea appears more abundant than natural in consequence of the water having diminished much more rapidly than it; and hence has arisen the erroneous idea that in fever, &c., it was actually increased in a given time. Two cases only were met with by Becquerel in which there was an increase in the normal quantity in 1000 parts. One was a case of milk fever, the other of sanguineous apoplexy. In the former it was in the proportion of 18.842 and in the latter of 16.452; 14, being the maximum in health according to this author. The amount excreted in twenty-four hours was only 133.492 and 190.076 grains respectively; thus showing that although there was a very considerable relative increase there was not only no augmentation in the natural quantity in the time specified, but, on the contrary, an actual diminution.

The importance therefore of accurately ascertaining the actual amount of urine passed in the twenty-four hours before we can positively state that an increased excretion of the solid ingredients of the urine has taken place in the same period, at once becomes apparent. Still if a greater amount of urine than natural continue to be passed, then the quantity of urea may increase likewise, although M. Becquerel states that he has never met with it, and is of opinion that it is an exceedingly rare occurrence. L'Héritier however mentions a case in which during the commencement of an attack of gout, he obtained from the urine of twenty-four hours, 23.160 grammes, or about 357.454 grains. The specific gravity was 1028.315 and the quantity of water 44 fluid ounces. And Dr. Prout has long since described two distinct kinds of cases characterised by an excess of urea, one with diuresis the other without. Instances of the latter, he says, are not uncommon in certain forms of dyspepsia. It is evident therefore, that as in examining the specific gravity, so also in ascertaining the quantity of urea three things must be considered. *First*, the quantity of water; *Secondly*, the age and sex of the individual, and *Thirdly*, the kind of food he has been taking,

for as we have seen from the researches of M. M. Lecanu (32) and Lehmann (33) it is subject to great variations in these respects. However we may generally calculate with a tolerable degree of certainty on an excess of this element whenever the specific gravity of the urine is above 1030.\*

35. According to Dr. Prout urea appears to be generated from the gelatinous tissues during the destructive stage of the secondary assimilating processes. Dumas states it to be "manifestly derived from the oxidation of the azotised materials of the blood," which he says "have a tendency to pass into a cyanic acid and oxide of ammonia." And in order to avoid any unnecessary expenditure of oxygen, nature wisely checks "the combustion of the azotised matter so soon as they are converted into cyanate of ammonia," which thus, immediately on its production, becomes transformed by an izomeric change of its elements, into urea.† Dr. Aldridge considers it, and in fact all the more essential elements of the urinary secretion, to be "derived from the combustion of the non eliminated secretions, and not directly from the decomposition of the tissues."‡ It exists in healthy blood only in very minute proportion owing to its being removed from it by the kidneys as soon as formed. Therefore any thing which interferes with the eliminating action of these organs will cause the urea to be retained in the blood, from which on analysis it can be readily separated. Prevost and Dumas removed the kidneys of different animals and found in five ounces of the blood of the dog above twenty grains of urea, and ten grains of it in two ounces of cat's blood.

Urea is the first organic substance that has been formed artificially. Dr. Prout made several unsuccessful attempts to form it, but the honour of doing so was reserved for Whöler a German chemist. (82)

36. *Uric* or *lithic acid* is one of the most important constituents of the urine. It has neither taste nor smell, and when pure is perfectly white, and crystallizes generally in rhomboid scales. It is insoluble in alcohol and ether, and but very sparingly soluble in water, requiring, according to

\* Prout on Urinary Diseases, p. 99. Fourth Edit.

† Med. Times, vol. xv. p. 258.

‡ Lectures on the Urine, p. 21.

Liebig, 15000 parts of cold and 1932 of hot; and according to Dr. Prout, 10,000 parts at 60 degs. for its solution. It is soluble however in caustic potash and nitric acid, and on evaporating the acid solution we obtain transparent almost colourless crystals of the erythric acid of Brugnatelli, the alloxan of Liebig, which assume a deep purple colour on the addition of ammonia, and constitute the purate of ammonia of Dr. Prout, the murexid of Liebig, and the purpurine of Dr. Bird. It is converted by heat into hydrocyanic acid, urea, carbonate of ammonia, and an empyrenatic oil. Exposed to the blowpipe it turns black, and becomes dissipated with the evolution of a very peculiar animal odour. It has but feebly acid powers, and its salts are readily decomposed by all acids. Its crystals, as they are met with in the urine, are always somewhat tinged by the colouring matters present in the secretion.

37. According to Liebig and Mitscherlich it is composed of:

	<i>Liebig.*</i>		<i>Mitscherlich.†</i>
Carbon . . .	36.083	—	35.82
Hydrogen . . .	2.441	—	2.38
Nitrogen . . .	33.361	—	34.60
Oxygen . . .	28.126	—	27.20

38. Its formula is  $C_{10}N_4H_4O_6$ , which may be said to represent four atoms of cyanogen, two of carbonic oxide, and four of water thus:

		C.	N.	H.	O.
1 atom uric acid -	-	= 10	+ 4	+ 4	+ 6
Equal to					
4 atoms cyanogen -	-	= 8	+ 4		
2 " carbonic oxide	=	2			2
4 " water -	-	=		4	+ 4
		<hr/>			
		10	+ 4	+ 4	+ 6
		<hr/>			

Or, from the fact of its being decomposed into oxalic acid, allantoin and urea when boiled in water with peroxide of lead, as shown in the following diagram.

\* Ann. der. Pharm., vol. x., p. 47.

† Poggend. Ann., vol. xxxiii., p. 335.





But as immediate reaction takes place between the hydrocyanic acid thus formed and water, there is then produced, by an interchange of elements formic acid and ammonia: or in other words formate of ammonia.

		C.	N.	H.	O.
1 atom hydrocyanic acid	=	2 +	1 +	1	
+ 3 " water - -	=			3 +	3
		<hr/>			
		2 +	1 +	4 +	3
	Equals				
1 atom formic acid -	=	2 +		1 +	3
1 atom ammonia -	=		1 +	3	
		<hr/>			
		2 +	1 +	4 +	3
		<hr/>			

39. Liebig states that when uric acid is acted on by oxygen, it is converted first into alloxan and urea, and subsequently by the further action of oxygen on the alloxan into either the oxalic or carbonic acid and urea.

The formation of alloxan and urea may be represented as follows:

1 atom uric acid -	-	=	10 +	4 +	4 +	6
plus 4 " water -	-	=			4 +	4
plus 2 " oxygen -	-	=				2
			<hr/>			
			10 +	4 +	8 +	12
	Equal to					
1 atom alloxan -	-	=	8 +	2 +	4 +	10
1 " urea -	-	=	2 +	2 +	4 +	2
			<hr/>			
			10 +	4 +	8 +	12
			<hr/>			

That of oxalic acid and urea from alloxan thus:

1 atom alloxan -	-	=	8 +	2 +	4 +	10
plus 1 " oxygen -	-	=				1
			<hr/>			
			8 +	2 +	4 +	11
	Equal to					
3 atoms oxalic acid -	-	=	6			9
1 " urea -	-	=	2 +	2 +	4 +	2
			<hr/>			
			8 +	2 +	4 +	11
			<hr/>			

And that of carbonic acid and urea from alloxan, thus:

			C.	N.	H.	O.
1 atom alloxan	-	-	=	8 +	2 +	4 + 10
plus 4 " oxygen	-	-	=			4
			<hr/>			
			8 + 2 + 4 + 14			
			Equal to			
6 atoms carbonic acid	-	-	=	6		12
1 " urea	-	-	=	2 +	2 +	4 + 2
			<hr/>			
			8 + 2 + 4 + 14			
			<hr/>			

Or the formation of the oxalic and the carbonic acids may be explained by the direct action of oxygen on uric acid itself; thus if we add

4 equivalents of water	-	=			4 +	4
and 3 " of oxygen	-	=				3
to 1 " of uric acid	-	=	10 +	4 +	4 +	6
			<hr/>			
we have the formula			10 + 4 + 8 + 13			
			Equal to			
2 atoms urea	-	-	=	4 +	4 +	8 + 4
3 " oxalic acid	-	=	6			9
			<hr/>			
			10 + 4 + 8 + 13			
			<hr/>			

And if we add three equivalents more of oxygen, we have then the composition of 2 atoms of urea and six of carbonic acid, thus:

4 atoms of water	-	=			4 +	4
plus 6 " oxygen	-	=				6
plus 3 " uric acid	-	=	10 +	4 +	4 +	6
			<hr/>			
			10 + 4 + 8 + 16			
			Equal to			
2 atoms urea	-	-	=	4 +	4 +	8 + 4
6 " carbonic acid	-	=	6			12
			<hr/>			
			10 + 4 + 8 + 16			
			<hr/>			

Hence then we have two probable sources of the oxalic and carbonic acids in the urine, one from the re-arrangement of the elements of urea (Bird,) (28,) the other from the oxidation of uric acid (Liebig.) A third may also be mentioned as being equally probable, namely, the perverted or mal-assimilation of the saccharine matter, (Prout,) (66 m.)

40. Lithic acid is supposed by Dr. Prout to be the result of the re-arrangement of the elements of the albuminous tissues.

41. According to Becquerel, about 8.1 grains are excreted in the course of twenty-four hours. In Table 2 we have stated the quantity at 9.999 grains. It exists in the urine, in all probability (as Dr. Prout has stated) in combination with ammonia, an opinion which appears to be greatly favoured by the comparative insolubility (36) of the acid, and by the fact that it is precipitated when any weak acid is added to the urine. Dr. Bird believes that it separates the ammonia from the double phosphate of soda and ammonia, a natural constituent of the healthy secretion, and by this means sets free phosphoric acid, which thus produces the natural acid reaction of urine, and which requires for saturation about 15 grains of carbonate of soda.

42. From the investigations of M. M. Lecanu and Lehmann however, we learn that the quantity, like that of urea, varies considerably according to the age, sex, diet, and exercise of the individual; but that in the same person, in a given time, but little variation is found to take place. Thus, M. Lecanu states the average in twenty-four hours to be

In adult men	.	.	.	.	13.153 grains.
In adult women	.	.	.	.	10.034 "
In old men	.	.	.	.	6.792 "
In young children	.	.	.	.	1.775 "

while M. Lehmann ascertained that his urine in the same time contained 18.25 grains after a mixed diet of animal and vegetable food; 22.70 when he restricted himself entirely to an animal diet; 15.76 after eating nothing but vegetables, and 11.26 when he confined himself to food perfectly free from nitrogen. Moreover, it has been found to be increased by alcoholic drinks (Bouchardat,) and diminished by much bodily exertion, (Lehmann.)

43. It is augmented when the cutaneous exhalation is impeded, and is also increased both absolutely and relatively in all cases of fever; in rheumatism and gout, and in diseases of the heart, lungs, and liver, being according to professor Andral, in cirrhosis, together with dropsy, an almost positive sign of the hepatic affection;\* but is diminished in chlorosis, anæmia, and other diseases, accompanied by great debility. This is decidedly opposed to the statement of Liebig that the uric acid disappears in proportion to the accelerated state of the circulation, and the amount of oxygen taken into the system. •

44. "Excluding all abstract theories," says Dr. Bird,† "whenever an excess of uric acid or its combination with bases occurs in the urine, a normal quantity of water being present (30 to 40 ounces in twenty-four hours,) it may safely be inferred that one or other of the following states exist.

A. Waste of tissue more rapid than the supply of nitrogenized nourishment, as in . . . . .	}	Fever, acute inflammation, rheumatic inflammation, phthisis.
--	---	--

B. Supply of nitrogen in the food greater than is required for the reparation and supply of tissue, as in . . . . .	}	Excessive indulgence in animal food, or the quantity of food remaining the same, with too little bodily exercise.
---	---	---

C. Supply of the nitrogenized food not being in excess, but the digestive functions unable to assimilate it . . . . .	}	All the grades of dyspepsia.
---	---	------------------------------

D. The cutaneous outlet for nitrogenized excreta being obstructed, the kidneys are called upon to compensate for the deficient function . . . . .	}	All or most stages of diseases attended with arrest of perspiration.
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E. Congestion of the kidneys produced by local causes . . .	}	Blows and strains of the loins, diseases of the genital apparatus."
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\* Med. Times, vol. 16. p. 156.

† Urinary deposits, p. 110.

45. When it exists in excess in the urine, it either becomes deposited as the fluid cools, or on the addition of an acid. (63.) The urine is also of a deeper colour than natural, contains in many cases a greater amount of urea, is somewhat increased in specific gravity, and has always an acid reaction on litmus. The urine of suckling infants, however, which not unfrequently contains an abundance of this element, has not these qualities; but is very pale, of exceedingly low weight, and, as we have seen, contains no urea.

46. Lithic acid is met with in the urine either combined with ammonia in the form of an amorphous sediment of a whitish, yellow, pink, purple, or red colour, according as it is mixed with the yellow colouring matter of the urine, with purpurine, or with both; or as a crystallized deposit constituting the red and yellow gravel, and also the variously coloured amorphous and pisiform concretions that have descended from the kidneys.

47. Urine containing an excess of lithate of ammonia presents the following varieties, Thus it is either (*a*) of a very pale colour reduced in density, and turbid in consequence of a whitish lithate being dispersed through it; or, (*b*) of a light amber hue, somewhat lower in density than natural, and depositing a yellowish or pale drab coloured sediment; or, (*c*) it is very high coloured, increased in specific gravity and with a reddish brown or brick-dust deposit; or, (*d*) lastly it may have a peculiar copper coloured, purple or crimson tint, owing to the presence of purpurine (6;) the deposits in these cases having always the same hue.

48. In gouty and rheumatic subjects lithic acid is frequently found united with soda, and the urate of soda thus formed is sometimes produced in such abundance that it not only renders the urine perfectly white, but also cannot be entirely got rid of from the system by the urinary secretion. It is therefore retained in it and eventually becomes deposited in and round the joints giving rise to those peculiar and characteristic, and often painful swellings called chalk stones.

49. The *natural acidity* of healthy urine has lately been accounted for by Liebig and Bird by the uric and hippuric acids acting on the alkaline phosphates, and either setting



free a portion of their acid or converting them into acid salts. (46)

50. *Hippuric acid*, so called from being present in large quantities in the urine of the horse, was formerly supposed to be peculiar to the urine of herbivorous animals. Lehmann, Wittstock, Ambrosiani, Muller, and Simon however, have ascertained its presence in that of diabetic patients; and Scheele, Prout, Fourcroy and Renard, in that of young infants; and Professor Liebig has lately proved it to constitute a natural ingredient of the healthy human excretion, in which he says it exists in nearly the same proportion as uric acid in combination with soda. Its composition is, according to Liebig, Dumas, Mitscherlich, and Bird, as follows :

	<i>Liebig.*</i>	<i>Dumas.†</i>	<i>Mitscherlich.‡</i>	<i>Bird.§</i>
Carbon . . . . .	60.742	- 60.5	- 60.63	- 63.93
Hydrogen . . . . .	4.959	- 4.9	- 4.98	- 4.64
Nitrogen . . . . .	7.816	- 7.7	- 7.90	- 8.21
Oxygen . . . . .	26.483	- 26.9	- 26.49	- 23.22

And its formula  $C_{18}, N_1, H_8, O_5, + H. O.$  Liebig states it, as well as the uric acid, to exist in the urine in solution with the phosphates of soda and potash; and he ascribes the fact, that these salts no longer possess in the urine, the alkaline reaction, peculiar to them when contained in the blood, to the presence of these two acids, and partly to the formation of a small portion of sulphuric acid as the result of the combustion of the sulphuric compounds contained in the system.

51. Hippuric acid crystallizes in long semi-transparent four-sided prisms, with dihedral summits, and has a somewhat bitter taste and a powerful acid reaction on litmus. It is soluble in about 400 parts of cold water, more soluble in boiling water, and still more abundantly in alcohol, by which therefore it can be readily separated from uric acid, which, as I have said, is insoluble in this menstruum; but

\* Ann. der Pharm., vol. xii. p. 20.

† Ann. de Chimie et de Physique, vol. lvii., p. 327.

‡ Poggend. Ann., vol. xxxiii. p. 335.

§ Urinary Deposits, p. 51.

is comparatively insoluble in ether. It becomes transformed into benzoic acid during the decomposition of the urine. It is also converted by nitric acid into the benzoic, and by sulphuric acid, with the addition of heat into the benzoic and carbonic acids and ammonia. Hydro-chloric acid dissolves it but does not decompose it. The addition of perchloride of iron to its aqueous solution produces a yellow colour. It is fused by a strong heat, and eventually becomes converted into a reddish coloured oil having an odour like that of Tonquin beans, ammonia, benzoic acid, and a black carbonaceous mass, and eventually into hydro-cyanic acid with the evolution of its peculiar odour.

52. Dr. Bird believes that the quantity represented by Liebig, as normally present in the urine, is not constant, but always much less than he has stated. He is of opinion, however, that hippuric acid, considering the abundance of carbon it contains, may possibly be one of the means by which this element may be eliminated, in large quantities, from the system by the kidneys, and that these organs may in those cases, where the lungs and liver, the proper emunctories of the carbon, do not effectually perform their functions, in some measure compensate for the deficiency, by excreting a larger quantity of hippuric acid. This is a subject well worthy of investigation. Mr. Stuart Cooper, in a memoir which gained the Corvizart prize for 1845, states the quantity to be in an inverse ratio with that of urea.

53. I know of only three well authenticated cases in which there was an excess of this acid in the urine. The first is described by M. Bouchardat under the title of hippuria,\* a disease characterized by excessive thirst, a harsh dry skin and an abundant secretion of watery urine, having an odour of whey, which contained only fourteen parts per 1000 of solid matters, 2.23 of which were hippuric acid, and no uric acid. The second is recorded by Dr. Garrod who obtained from about six ounces of urine as much as half a drachm of the acid, and this for several days together. A remarkable feature in this case is that this excess was met with during the administration of small doses of muriate of

\* Loc. Cit.

morphia for a superabundance of urea, and a deposition of the triple phosphate of ammonia and magnesia, which had been previously met with in the urinary secretion of the patient. The uric acid in this case was not in the least diminished in quantity. The third occurred in a young female aged thirteen affected with chorea, who had lived for some time on nothing but bread and water and apples. M. Pettenkofer examined her urine which was of a limpid yellow colour, and states that it contained as much as 1.2286 per cent of hippuric acid.\*

54. According to Liebig hippuric acid is derived from the non-nitrogenized elements of food ; and we learn from the experiments of Wöhler, Ure, and Keller, that benzoic acid when administered internally becomes converted into the hippuric with the disappearance of the urea, and, according to Dr. Ure, of the uric acid, also. Dr. Garrod has, however, proved this to be a mistake, and in this statement he is confirmed by the researches of Dr. James Booth and M. H. Boyè of Philadelphia, from which it results ; *First*, That the uric acid suffers no alteration, either in quantity, or in its external properties, by the exhibition of benzoic acid and its subsequent metamorphosis into the hippuric. *Secondly*, That this metamorphosis is apparent in the urine in from twenty to forty minutes after the benzoic acid has been taken, and continues to be so for eight hours; *Thirdly*, That the quantity of hippuric acid obtained from the urine exceeds by about one-third, that of the benzoic acid taken ; *Fourthly*, That the hippuric acid is not combined with the urea in the urine, but that, *Fifthly*, it is united with and kept in solution by ammonia,† and not soda as has been stated by Liebig. Dr. Bird explains the conversion of the benzoic into the hippuric acid by supposing four atoms of the former and one of urea to act on 48 of oxygen and become converted into two atoms of the latter, 44 of carbonic acid, and 8 of water. Drs. Liebig and Garrod give a different explanation ; they account for the transformation by supposing two atoms of benzoic acid to act on the *elements* of one atom of lactate of urea and produce two atoms of the acid in question.

\* See Liebig and Wöhler's *Annalen*, vol. 50.

† *Med. Gaz.* for Nov. 21, 1845, p. 1286.

55. The presence of *Lactic acid* and its compounds in the urine has been disproved by Liebig, who on repeating the experiments of Berzelius, discovered a particular crystallizable substance, that had not been previously described, and which he believes to have been mistaken for them. This new matter appears to be very rich in carbon and nitrogen, and therefore it is the more to be wondered at that it should have been confounded with lactic acid, a compound entirely free from the latter element.

56 The normal proportion of this acid in 1000 parts of healthy urine cannot, I think, be considered as decided even supposing it to exist there. Becquerel believes it to constitute the greater portion of what he terms the inseparable organic matters, which according to him, vary between 7 and 10 parts in 1000, and to exist partly in a free state and partly in combination with ammonia, soda, and urea. M. Lehmann states the average amount of free lactic acid to be 1.525, and that of combined lactic acid 1.160, making a total of 2.685 parts in the quantity stated. The mean daily quantity of free lactic acid discharged, according to the same observer was :

After a mixed Diet	-	-	-	-	-	23.68 grains.
„ an Animal Diet	-	-	-	-	-	33.45 „
„ a Vegetable Diet	-	-	-	-	-	18.35 „

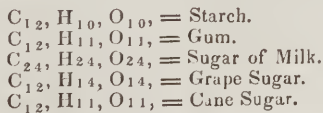
While that of combined lactic acid was :

After a mixed Diet	-	-	-	-	-	18.12 grains.
„ Vegetable Diet	-	-	-	-	-	21.16 „

57. The composition of this acid is :

Carbon	-	-	-	-	-	44.90
Hydrogen	-	-	-	-	-	6.11
Oxygen	-	-	-	-	-	48.99*

And its formula  $C_6, H_5, O_5$ . It is therefore greatly allied to



\* Liebig's Animal Chemistry, p. 309.



Its composition may be represented as follows :

Carbon	-	-	-	-	-	-	-	39.37
Nitrogen	-	-	-	-	-	-	-	33.63
Hydrogen	-	-	-	-	-	-	-	6.79
Oxygen	-	-	-	-	-	-	-	20.21

59. *Extractive Matters*.—These are certain organic nitrogenous principles, combined, in the opinion of Dr. Aldridge, with some substance resembling sugar or dextrine, which remain in combination with the saline constituents of the urine after the urea and lithic acid have been removed. They consist principally of the colouring matter already described (6,) and which is considered by Scherer to be analogous to both that of the bile and blood ; are entirely dissolved by water, less so by rectified spirit, and still less by alcohol ; hence their division by the last named writer, into the *water extract*, the *spirit extract*, and the *alcohol extract*. They are composed of carbon, hydrogen, oxygen, nitrogen, and sulphur. Their watery solution very speedily undergoes the putrefactive fermentation, a very fœtid disagreeable odour being then evolved, and a large quantity of acetic acid generated. During this process the presence of sulphur is manifested by the glass vessel in which it is allowed to take place, becoming blackened. On burning the extract in a test tube over a spirit lamp fumes of ammonia are disengaged, and may be detected in the usual way, namely, by holding a glass rod dipped in strong hydrochloric acid, or the wetted stopper of the bottle containing it, over the mouth of the tube, a black carbonaceous mass being left behind. The spirit extract also generates acetic acid in considerable quantity during its putrefaction, and on being heated gives off, according to Dr. Aldridge,\* a pyroligneous oil, water, carbonate of ammonia, and leaves a porous charcoal. The alcohol extract, on the other hand, that is, that portion of the extractive matters, which in the words of Dr. Aldridge is “precipitable in white flocks from a concentrated watery solution by the addition of anhydrous alcohol,” does not produce any acetic acid by putrefaction. Thus then we are now able to explain the

\* Lectures on the Urine, p. 11.



cause of the decomposition which always takes place in the urine by keeping, and the origin of the acetic acid which is frequently found in it. Prout it is true some years ago proved its existence in the secretion by distilling the latter with sulphuric acid ;\* and Liebig has more lately ascribed its presence to the putrefaction of the colouring matters of the urine, which, he says, become converted by this process into the acid in question and a brown resinous highly azotised substance.† But, thanks to the labours of Scherer, we now know what particular portion of the urinary extractive it is that becomes transformed by decomposition into the acetic acid.

60. In Table 2, I have represented the quantity of extractive and colouring matter with muriate of ammonia passed in the twenty-four hours to be 140.929 grains. The amount was found by Lehmann to be considerably influenced by diet, the greatest proportion being excreted after vegetable food. The following are the results of his investigations:

After a vegetable diet . . . .	254.929 grains.
After an animal diet. . . .	80.215 “
After a mixed diet . . . .	161.711 “
And after a non-nitrogenous diet . .	182.940 “

The quantity is also considerably diminished by exercise, the mean daily amount during a pedestrian tour, being 130.528 grains according to the last named author.

61. The quantity of *Fixed saline matters* in healthy urine is stated by Becquerel to average about 140 grains in the 24 hours. This is hardly enough for this country at least ; that given in the table I have constructed from Dr. Christison's formula will probably be found more correct. Lecanu found the quantity to fluctuate between 75 and 378 grains, the following are the results of his analysis :

	Max.	Mean.	Min.
In Men . . . .	378	265	153 grains.
Women . . . .	302	234	166 “
Children of about 8 years	168	160	152 “
Old men . . . .	151	122	94 “

\* Annales de Physique et de chimie, vol. 14, p. 260.

† Lancet, June 1, 1844.

Becquerel gives 7.695 grains as the mean amount he obtained from 1000 parts of urine from four healthy men, and 6.143 grains from the same quantity from four healthy women; while the mean result of six analyses of the morning urine of a healthy man made by Dr. Day was 9.27 in 1000 parts.

62. These saline matters are derived partly from the food and partly from the metamorphoses constantly taking place in the tissues. Thus the alkalies, potash and soda, are furnished by the blood and the albuminous tissues, and the earths lime and magnesia by the fibrinous and muscular structures. The hydro-chloric acid appears to be derived principally from the common salt we eat, and the sulphuric and phosphoric acids in great part from the oxidation of the sulphur and phosphorus contained in the albuminous and fibrinous tissues; the former in the proportions of 0.68 and 0.36, and the latter of 0.33 and 0.33 respectively. The presence of sulphuric acid in the urine may likewise be partly ascribed to the oxidation of the sulphur recently discovered by Professor Redtenbacher in taurine, a substance obtained by the decomposition of the choleic acid of the bile, in the proportion of nearly twenty-six per cent,—25.70. It exists in the urine in combination with potash and soda, in the proportion, according to Professor Dumas,\* of from 30.7 to 57.6; while the phosphoric acid is found united with both the earths and the alkalies; the earthy phosphates varying from one-fourth to one-eighteenth and the alkaline phosphates from three-fourths to seventeen-eightieths. (Dr. Bence Jones.)

It is evident, therefore, that these salts must be subject to considerable variation in quantity both in health, in consequence of the difference in the composition of the various articles of food we take, and also in disease. In the latter they are generally absolutely diminished and to this Becquerel appears to have met with but one well marked exception. It was in the case of a girl convalescent from chlorosis accompanied by pulmonary emphysema, in which it was 32.759 grains above his highest normal standard. In this instance, however, it had increased conjointly with

\* Med. Times, vol. xvi. p. 71.

the water which amounted to upwards of 32 ounces. A relative increase, however, is by no means uncommon, especially in febrile and inflammatory infections. Independent of the alteration in the quantity of these saline matters taken together, variations in their relative proportions to each other also frequently occur. The greatest differences have been observed in the earthy phosphates; Lecanu indeed found them to oscilate between 0.56 and 30.2 grains. Some very interesting researches have lately been made by Dr. Bence Jones relative to this subject. Thus it appears from the results of his investigations, that the urine passed soon after eating a meal, no matter whether it consists of animal food or only of bread, contains a much larger quantity of the *earthy* phosphates than that voided at other times; whereas the proportion contained in that excreted after long fasting, is greatly diminished. The *alkaline* phosphates on the contrary, become very remarkably decreased in quantity after a purely meat diet, and augmented in the greatest degree when bread alone is taken. Exercise, on the other hand, he found not to affect the earthy phosphates, but to occasion an increase of the alkaline phosphates to the extent of nearly one-third. A considerable augmentation in the amount of the *earthy* phosphates is also occasioned by the exhibition of the chloride of calcium and the carbonate and sulphate of magnesia. The same author also ascertained a remarkable difference in the quantity of phosphates excreted with the urine during certain diseases of the brain. For instance, in inflammation of the brain he found the quantity to be much greater than in delirium tremens; the average in three cases of the former being 8.26 per 1000 urine sp. gr. 1.025,3, and in three cases of the latter only 0,67 per 1000, sp. gr. 1.020.4. Great mental exertion tends likewise very materially to increase the amount of phosphates. The average amounts of the earthy phosphates obtained by Lehmann in the 24 hours were as follows:

After an animal diet	.	.	.	.	34.990 grains.
“ a mixed diet.	.	.	.	.	17.414 “

The quantity of chloride of sodium also varies remarkably in adult men and women. Thus, while in the former it

may be stated to average between 30 and 70 grains, in the latter, and likewise in old men, it scarcely ever reaches above 10 or 11 grains, and has been found even as low as 0.26 grains. From the urine of dying persons, it is according to Prout, almost entirely absent. Lecanu found it to fluctuate between 0.26 and 116 grains in 24 hours in different individuals.

63. According to Berzelius *sulphur* exists in the urine not only as sulphuric acid, but also in some particular state of combination not yet defined; and Mr. John T. Barry has, by repeating and modifying the experiments of the Swedish chemist, detected a very tolerable proportion of it. Dr. Bird also states, on the authority of Dr. Edmund Ronalds, that from three to five grains of sulphur in a compound form are excreted with all urine in the course of twenty-four hours. According to Dr. Ronalds the sulphuric acid bore to the non-oxydised sulphur, in five different specimens of healthy urine the following proportions:

$$1.06 : 0.17 — 146 : 0.18 — 1.42 : 0.18 — 2.44 : 0.153 \\ 1.32 : 0.165$$

64. The quantity of *Mucus* contained in healthy urine is generally very small, and from its transparency, invisible. In some cases, however, as the excretion cools it becomes slightly opaque and forms a distinct cloud near the base of the containing vessel, constituting what is termed an *eneorema*. In females during the menstrual period it is more abundant, and from being somewhat altered in its properties, by having lost its natural transparency, can always be distinctly observed. Lecanu found it to vary in six different individuals (male) from 4.6 to 26.5 grains, and from 3.3 to 5.68 grains in various women and old men. In certain diseases it becomes considerably increased in quantity as will be more particularly alluded to hereafter. (118) When examined under the microscope it has a nucleolo granular appearance and is found to contain several exfoliated epithelial scales.

65. *Butyric acid* is a compound which Berzelius states may be procured in small quantities from urine when it is distilled with sulphuric acid. Dr. Prout, however, appears

from the following passage at page 568 of his celebrated work "neither if we except the lactic acid does any form of the saccharine principle exist in healthy urine" to doubt its existence in the normal secretion, and is of opinion that it is only present during some particular derangement in the assimilation of the saccharine matters. It may therefore, I think, be considered as intermediary between the preceding healthy constituents of the urine and the abnormal ingredients frequently present in it during certain morbid states of the system; and which now remain to be described. M. Lehmann found it to exist in rather large quantities during the first week after labour, in the urine of a female who did not suckle her child.

66. The *Abnormal ingredients* may be divided into two classes. The first contains those matters resulting from the various alterations or decompositions which take place in the renal secretion; and the second those of an organic and inorganic nature which have either been secreted with the urine, or which have entered it in consequence of some pathological change having taken place in some part of the urinary passages. They may be conveniently arranged in the following

# TABULAR VIEW.

## CLASS I.

Occasioned by.	<div> <div>Carbonate of lime . . . .</div> <div>Carbonate of magnesia . .</div> <div>Neutral phosphate of lime .</div> <div>Neutral triple, or ammonia-co-magnesian phosphate .</div> <div>Basic triple phosphate . .</div> </div>	<div> <div>I. The rearrangement of the elements of urea and water producing carbonate of ammonia. (<i>a.</i>) <i>Previous to secretion</i> . . . . .</div> <div> <div>II. The rearrangement of the elements of urea and water producing carbonate of ammonia. (<i>b.</i>) <i>Subsequent to secretion—change taking place in the bladder</i> . . . . .</div> <div> <div>III. The rearrangement of the elements of urea and water, producing carbonate of ammonia. (<i>c.</i>) <i>Subsequent to secretion—change taking place out of the bladder</i> . . .</div> </div> </div></div>	<div> <div>A low kind of inflammation or irritation of the kidneys.</div> <div>In consequence of</div> <div> <div>Injury to, or disease of, spinal marrow.</div> <div>Injury to the loins.</div> <div>Depression of the vital powers.</div> <div>Nervous irritability, or exhaustion.</div> <div>Disease of, or stone in the bladder.</div> <div>Enlarged prostate.</div> <div>Stricture of urethra.</div> </div> </div>	<div> <div>The natural decompositions which the urine undergoes by keeping.</div> </div>

IV. Some kinds of indigestion.

V. The immoderate use of alkalies.

VI. The internal administration of mercury in large quantities.





d. Torulae the result of . . .	Saccharine matter in the urine.
e. Vibriones, cause . . .	Unknown, apparently connected with great prostration of strength.
f. Spermatozoæ . . .	<div> <div> <div>the result of.</div> <div> <div>1. Involuntary seminal emissions.</div> <div>2. Coitus.</div> <div>3. The passage of the spermatie fluid into the bladder in consequence of stricture of the urethra.</div> </div> </div> </div>
	(B.) Non Organized.
g. Albumen . . .	<div> <div> <div>the result of</div> <div> <div>1. Congestion of the kidneys</div> <div> <div> <div>From external injury.</div> <div>From the retrocession of a cutaneous eruption.</div> <div>From febrile states of the system.</div> <div>From impeded respiration.</div> <div>From checked perspiration.</div> <div>From weakness of the vessels.</div> <div>From pressure on renal veins.</div> <div>From large doses of mercury and stimulating diuretics.</div> </div> </div> </div> </div> </div>
	<div> <div> <div>2. Granular degeneration of the kidneys.</div> <div>3. An inflammatory state of the kidneys in Scarletina. (Prout.)</div> <div>4. A diseased state of the blood.</div> </div> </div>
h. Bile . . .	<div> <div> <div>the result of</div> <div> <div>1. Certain diseases of the liver.</div> <div>2. Obstruction to the flow of bile into the intestines.</div> </div> </div> </div>
i. Milk and oil . . .	Mixed with the urine for the purposes of deception.
k. Kiestien, the result of . . .	Pregnancy.
l. Fatty matter, id. . .	Mal-assimilation of albuminous matters.
m. False Membranes, id. . .	Blisters of Spanish fly. (Morel Lavallée.)

<i>u.</i> Sugar, the result of . . .	{	1. Mal-assimilation of saccharine matters. (Prout )
		2. Fermentation of the Epithelium. (Aldridge.)
<i>o.</i> Oxalic acid . . . . .	{	1. Slight deoxidation of the elements of urea and water. (Bird.)
Oxalate of Ammonia . . .		2. Oxidation of uric acid. (Liebig.)
	{	3. Mal-assimilation of certain articles of food.
<i>p.</i> Sugar . . . . .		{
and		
Oxalic acid . . . . .	{	1. Of saccharine matters.
		2. Of gelatinous matters.
	{	3. Of albuminous and oleaginous matters
		assimilation.
<i>q.</i> Carbonic acid . . . . .	{	Deoxidation of the elements of urea and water.
and		
Carbonate ammonia . . .	{	
<i>r.</i> Acetic acid . . . . .	{	1. Fermentation of the extractive matters.
and		
Ammonia . . . . .	{	2. id. id. epithelium.
<i>s.</i> Lactic acid, the result of .	{	id. id. id.
<i>t.</i> Uric . . . . .	{	1. Probably of perverted assimilation of the albuminous tissues.
or,		
Xanthic oxide . . . . .	{	2. id. id. id. nitrogen of food.

1. Probably of perverted assimilation of the albuminous and gelatinous tissues.
2. Of imperfect secretion of bile.
3. Of Oxidation of the tissues as in chlorosis. (Shearman.\*)

# INORGANIC MATTERS.

The water drank. (Berzelius.)

Their internal administration.

Their internal or endermic administration.

Unknown.

1. The rearrangement of the elements of urea and water *after secretion*, producing cyanate of ammonia, and the presence of iron in the urine.
2. The rearrangement of the elements of urea and water *before secretion*, producing cyanate of ammonia, which acts on the iron of the blood.

Unknown.

\* See Dr. Bird's work, p. 150.

u. Cystine . . . . .	the result of
v. Silicic acid arising from . . . . .	
w. Iodine, iron, . . . . .	the result of
Indigo . . . . .	
x. Arsenic, Antimony, . . . . .	the result of
Mercury . . . . .	
y. Cyanourine, cause of . . . . .	the result of
z. Percyanide of iron . . . . .	
a.a. Melanourine, cause . . . . .	

## CHAPTER III.

67. HAVING spoken, in the foregoing pages, of the composition of healthy urine and of the various modifications it is liable to undergo both in health and disease, it now remains for me to describe the mode of obtaining this information, or in other words, the process by which the nature of the different natural and unnatural urinary constituents can be ascertained. This will form the subject of the present chapter.

68. From what has been already said, it is evident that in examining the urine, it is always necessary to previously discover when it was passed, and then to commence by noticing its physical properties and its acid or alkaline reaction; for by this means we become possessed of certain facts by which we are better enabled to regulate our subsequent analytic researches.

69. We should begin then by making ourselves acquainted with the colour, odour, transparency, and consistence of the urine, and then with its density, quantity, and chemical reaction on test paper. By its *colour* (4) we judge, *First*, of its degree of concentration or dilution and consequently of the amount of solid ingredients; *Secondly*, of the presence of certain foreign matters, and *Thirdly*, of certain morbid states of the system. By its *odour*, (3,) we not only ascertain whether decomposition has taken place or whether some foreign odoriferous principles are present, but we are also enabled to suspect the existence of certain diseases. By a *deviation from its natural transparency* (9,) we discover either that some of its natural constituents are in excess; that it contains some abnormal element, or that some change has taken place in it by decomposition. By an *increase in its consistence*, (10) we detect the presence of mucus, pus, albumen, sugar, and even in some cases of oxalate of lime. By its *density* (11) and *quantity*, (7) we

are not only enabled to ascertain the amount of solid matters present in a given specimen, and the quantity excreted in a certain time, but are also led to infer either that certain elements are diminished or in excess, or that some abnormal ingredient is present, or even the existence of some particular malady. Thus (by way of illustration,) two distinct classes of cases may present themselves. In the first the urine is low in density, and either normal, diminished, or increased in quantity. If it be normal or diminished we have positive proof that the amount of its constituents is reduced; the extent of the reduction being exactly in proportion to the decrease in the quantity and specific gravity; while, if it be increased, no such reduction may have taken place, but on the contrary, the actual quantity of solid matter excreted may be perfectly normal, in fact, augmented. In the second class, the urine is of high specific gravity, and its quantity either natural, decreased or augmented. If it be natural it is a certain sign that a greater amount of solid matter is held in solution. If it be decreased, which is most commonly the case, it shows that the quantity of solids has either remained unaltered, or that it has not diminished in the same proportion as their solvent. If it be augmented, it is a certain criterion that a much larger amount of solid is excreted than natural, and affords us a valuable means for ascertaining the cause of the emaciation that occurs in some cases. Lastly, by its *acid neutral, or alkaline reaction*, (2, 41, 29.), our former suspicions respecting the cause of the change in its colour, odour, transparency, and consistence, become in a great measure confirmed. For instance, suppose we find the urine thick or turbid, strong smelling, and high coloured, with a reddish or pinkish coloured deposit and *acid*, we know immediately that there is an excess of the lithates in combination with purpurine, (6, 46, 47;) while if it be pale, opaque, covered with a pellicle presenting numerous colours like the surface of a soap bubble, and *alkaline*, or perhaps, somewhat acid, we then strongly suspect an excess of the phosphates, more especially if the urine is alkaline, has a foetid ammoniacal odour, or contains a large quantity of mucus, (29,) which, as I have before said, is liable to



act as a ferment, and by thus effecting the decomposition of the urea causes a deposit of the earthy phosphates.

The valuable information that is thus derived from the examination of the physical properties and chemical reaction of the urine is obtained in a very short time and with little trouble.

70. To ascertain the chemical reaction of the urine, blue and red litmus paper should be employed. The former will be changed to red if the urine be acid and the latter to blue if it be alkaline, but if it be neutral neither will be acted on. These test papers are now conveniently arranged in small books by Griffin of Glasgow.

71. The density may be obtained in two ways, either with the specific gravity bottle,\* which is the most correct; or with, what is more commonly used, the urinometer, an instrument consisting of a stem graduated from 0 to 60 degrees and two bulbs, the lower one being, partially or quite filled with mercury in order to increase the weight of the instrument. It may be purchased at any Philosophical Instrument Makers, conveniently arranged in a case, containing a cylindrical glass vessel in which the urine to be examined is intended to be placed, a test tube, a bottle for nitric acid, a watch glass, and test paper.

In using it, all that is required to be done is to place it in the urine contained in the glass vessel just alluded to, and then to carefully note the figure corresponding to the surface of the fluid which will be the density of the latter; or, as Dr. Bird recommends, the degree *immediately below it* in order "to compensate for the errors arising from capillary adhesion of the urine to the glass."

72. In estimating, however, the specific gravity, it is necessary for the urine to be perfectly clear and free from impurities; therefore, when turbid, either from the presence of foreign bodies, or from the precipitation of some of its natural constituents, these must be previously removed by filtration; and it behoves us also at all times, as I have before said, to pay strict attention, both to the temperature,

\* The specific gravity bottle holds exactly 1000 grains of distilled water, therefore the density of any other fluid will be represented by the increase above 1,000.

(which should be about 60 degs. Farnh.) and the quantity of the excretion in twenty-four hours ;(7.14) and when it is desirable to come to some correct conclusion with respect to the nature of the urine in that time, we must always endeavour to collect, if possible, the whole that is passed, and then to submit a portion of the mixture to examination ; for it is evident that the results that are otherwise obtained can have reference only to the particular specimen examined. Another source of fallacy also requires to be avoided, viz., the sinking of the instrument too rapidly in the fluid, for if any of this collect on the stem above the degree corresponding to its density, it will cause the instrument to descend so much lower, and consequently indicate a less specific gravity than the fluid in reality possesses.

73. Various tables have been constructed by different authors, by which it is proposed to calculate the solid amount of matter contained in a given quantity of urine, from the specific gravity of the secretion. These tables are all based on the now well-known fact that the proportion of the solid contents of one thousand parts of urine is equal to the excess of its density over that of water multiplied by a given number ; this number being, according to Dr. Henry, 2.58 ; according to M. Becquerel, 1.65, and according to Dr. Christison, 2.33. Now it must be evident to every one, from the great difference existing between these three amounts that fallacy must exist somewhere. Dr. Day has, however, proved, by numerous experiments, that the formula of Dr. Christison, viz.  $\Delta + 2.33$ , in which  $\Delta$  represents the difference between 1000 grains and the density, is far more accurate than either of the others.

I have therefore from it formed the following tables which, as they prove each other, may be relied on for their accuracy.

TABLE III.

*Showing the amount of water and the proportion of solids in a fluid ounce at different densities.*

Specific Gravity.	Amount of water in one fluid oz. in grains.	Weight of solids in 1 fluid oz. in grains.	Specific Gravity.	Amount of water in one fluid oz. in grains.	Weight of solids in 1 fluid oz. in grains.
1000	437.50	.. ..	1029	407.92	29.58
1001	436.48	1.02	1030	406.90	30.60
1002	435.46	2.04	1031	405.88	31.62
1003	434.44	3.06	1032	404.86	32.64
1004	433.42	5.08	1033	403.84	33.66
1005	432.40	5.10	1034	402.82	34.68
1006	431.38	6.12	1035	401.80	35.70
1007	430.36	7.14	1036	400.78	36.72
1008	429.34	8.16	1037	399.76	37.74
1009	428.32	9.18	1038	398.74	38.76
1010	427.30	10.20	1039	397.72	39.78
1011	426.28	11.22	1040	396.70	40.80
1012	425.26	12.24	1041	395.68	41.82
1013	424.24	13.26	1042	394.66	42.84
1014	423.22	14.28	1043	393.64	43.86
1015	422.20	15.30	1044	392.62	44.88
1016	421.18	16.32	1045	391.60	45.90
1017	420.16	17.34	1046	390.58	46.92
1018	419.14	18.36	1047	389.56	47.94
1019	418.12	19.38	1048	388.54	48.96
1020	417.10	20.40	1049	387.52	49.98
1021	416.08	21.42	1050	386.50	51.00
1022	415.06	22.44	1051	385.48	52.02
1023	414.04	23.46	1052	384.46	53.04
1024	413.02	24.48	1053	383.44	54.06
1025	412.00	25.50	1054	382.42	55.08
1026	410.98	26.52	1055	381.40	56.10
1027	409.96	27.54	1056	380.38	57.12
1028	408.94	28.56	1057	379.36	58.14

TABLE IV.

*Showing the amount of water and the quantity of solid matter contained in one pint of urine at different densities.*

Specific Gravity.	Amount of water in one pint.	Weight of solids in one pint in grains.	Specific Gravity.	Amount of water in one pint.	Weight of solids in one pint in grains.
1000	8750.000	.....	1029	8158.400	591.600
1001	8729.600	20.400	1030	8138.000	612.000
1002	8709.200	40.800	1031	8117.600	632.400
1003	8688.800	61.200	1032	8097.200	652.800
1004	8668.400	81.600	1033	8076.800	673.200
1005	8648.000	102.000	1034	8056.400	693.600
1006	8627.600	122.400	1035	8036.000	714.000
1007	8607.200	142.800	1036	8015.600	734.400
1008	8586.800	163.200	1037	7995.200	754.800
1009	8566.400	183.600	1038	7974.800	775.200
1010	8546.000	204.000	1039	7954.400	795.600
1011	8525.600	224.400	1040	7934.000	816.000
1012	8505.200	244.800	1041	7913.600	836.400
1013	8484.800	265.200	1042	7893.200	856.800
1014	8464.400	285.600	1043	7872.800	877.200
1015	8444.000	306.000	1044	7852.400	897.600
1016	8423.600	326.400	1045	7832.000	918.000
1017	8403.200	346.800	1046	7811.600	938.400
1018	8382.800	367.200	1047	7791.200	958.800
1719	8362.400	387.600	1048	7770.800	979.200
1020	8342.000	408.000	1049	7750.400	999.600
1021	8321.600	428.400	1050	7730.000	1020.000
1022	8301.200	448.800	1051	7709.600	1040.400
1023	8280.800	469.200	1052	7689.200	1060.800
1024	8260.400	489.600	1053	7668.800	1081.200
1025	8240.000	510.000	1054	7648.400	1101.600
1026	8219.600	530.400	1055	7628.000	1122.000
1027	8199.200	550.800	1056	7607.600	1142.400
1028	8178.800	571.200	1057	7587.200	1162.800

TABLE V.

*Showing the proportion of fluid and solid in 1000 grains of the secretion at various specific gravities.*

Specific Gravity.	Amount of water in 1000 grains.	Amount of solids in 1000 grains.	Specific Gravity.	Amount of water in 1000 grains.	Amount of solids in 1000 grains.
1001	997.67	2.33	1029	932.43	67.57
1002	995.34	4.66	1030	930.10	69.90
1003	993.01	6.99	1031	927.77	72.23
1004	990.68	9.32	1032	925.44	74.56
1005	988.35	11.65	1033	923.11	76.89
1006	986.02	13.98	1034	920.78	79.22
1007	983.69	16.31	1035	918.45	81.51
1008	981.36	18.64	1036	916.12	83.88
1009	979.03	20.97	1037	913.79	86.21
1010	976.70	23.30	1038	911.46	88.54
1011	974.37	25.63	1039	909.13	90.87
1012	972.02	27.96	1040	906.80	93.20
1013	969.71	30.29	1041	904.47	95.53
1014	967.38	32.62	1042	902.14	97.86
1015	965.05	34.95	1043	899.81	100.19
1016	962.72	37.28	1044	897.48	102.52
1017	960.39	39.61	1045	895.15	104.85
1018	958.06	41.94	1046	892.82	107.18
1019	955.73	44.27	1047	890.49	109.51
1020	953.40	46.60	1048	888.16	111.84
1021	951.07	48.93	1049	885.83	114.17
1022	948.74	51.26	1050	883.50	116.50
1023	946.41	53.59	1051	881.17	118.83
1024	944.18	55.92	1052	878.84	121.16
1525	941.75	58.25	1053	876.51	123.49
1026	939.42	60.58	1054	874.18	125.82
1027	937.09	62.91	1055	871.85	128.15
1028	934.76	65.24	1056	869.52	130.48

74. Having obtained then the specific gravity in the manner above recommended, we refer at once to Tables 3 or 4 for instance, and we there find corresponding to it, the amount of solids contained either in an ounce or a pint of the urine, and then by a simple multiplication we can readily discover the actual quantity excreted in twenty-four hours. To illustrate this, let us suppose the urine to be healthy, that is of specific gravity 1020 and about 35 fluid ounces in quantity. By looking at the tables we find at this density, one fluid ounce contains 20.40 grains, and a pint 408 grains of solids. If then we multiply 20.40 by 35, or add to 408, the result that will be obtained by multiplying 20.40 by 15, the surplus above a pint, the quotient will be the amount sought for, thus:—

$$\begin{array}{rcl} 20.40 \times 35 & = & 714 \\ 20.40 \times 15 + 408 & = & 714 \end{array} \left. \vphantom{\begin{array}{rcl} 20.40 \times 35 & = & 714 \\ 20.40 \times 15 + 408 & = & 714 \end{array}} \right\} \text{grains in 35 fl. ounces.}$$

Dr. Bird has constructed a Table\* by which he proposes to calculate the amount of solids contained in a pint of urine by multiplying the weight of the latter by the quantity of solid matter found by Table V., to exist in 1000 grains, and these dividing by 1000. But the results obtained from it do not coincide with those given in the preceding Tables.

75. In consequence, however, of the various densities of the different elements of the urine, of the various relative proportions in which they exist in it, and also of the foreign matters with which it is frequently contaminated, Tables thus constructed can never do more than give an approximation to the truth. Still they are sufficient for practical purposes. When, therefore, greater accuracy is required, another mode of proceeding must be adopted, which consists in the evaporation of the urine. For this purpose Simon recommends us first to ascertain its specific gravity at the temperature of 60 Farhn., and then to evaporate about 25 grains of it over a steam bath to the consistence of a thin extract in a previously weighed light porcelain dish or capsule, the edges of which must be perfectly even, so that when covered by a piece of glass (the weight of which should be known) all air may be excluded. The

\* Loc. Cit. p. 38.



dish with the residue thus obtained, is then to be placed in the vacuum of an air pump over strong sulphuric acid, and allowed to remain for a period of from thirty-six to forty-eight hours, when it is to be removed, care being taken to cover it directly with the piece of glass above mentioned, in order to prevent the dry mass which remains from absorbing moisture from the surrounding atmosphere. The capsule is now to be weighed, and the increase above its known weight and that of the glass will represent the amount of solid in the quantity of urine examined. We have then only to multiply this by  $17\frac{1}{2}$  to ascertain how much is contained in an ounce, and the product obtained multiplied by the number of ounces voided in the twenty-four hours will give the actual quantity, excreted in that time.

76. Having now made ourselves acquainted with the density, and formed, with the assistance of the Table, a tolerably correct idea of the amount of solid matters contained in the urine, our next step is to ascertain the quality of the secretion. This can generally be sufficiently effected for practical purposes, by means of heat and nitric acid. Heat will throw down any albumen that may be present, provided the urine is not alkaline, and likewise the phosphates when in excess. The latter are distinguished from the former by being re-dissolved by a few drops of nitric acid. Heat, when raised to the boiling point, will even precipitate the phosphates when not increased in quantity, as has been observed by Dr. Rees, and more recently by Dr. Schaffner who explains the circumstance by the fact that at this temperature they, that is the earthy phosphates, become decomposed into subphosphates which are deposited. It will also dissolve a deposit of the lithates, but not of lithic acid or of the phosphates. It also alters the unnatural colour given to the urine by blood and disturbs the transparency of the secretion by coagulating the albuminous matter. Nitric acid will precipitate the lithic acid if it exist in excess, and detect a superabundance of urea. (78) It will throw down albumen, dissolve the phosphatic deposits, and also the lithates with the deposition of the lithic acid in a crystallized state, and detect the presence of bile by producing a rapid and interesting display of colours in a thin layer of

the urine containing it, but will not affect the purulent or mucus sediments. It sometimes happens, however, that the urine not only contains albumen, but is at the same time turbid from the deposit of phosphates; and, as in this case, the disappearance of the latter, when nitric acid is added, is frequently marked by the coagulation of the former by the same re-agent, it follows that an error in diagnosis would in consequence very frequently result, especially if, from the alkaline condition of the urine heat had no power in solidifying the albumen, were we not aware of the possibility of such an occurrence, and likewise of the best means of detecting it. When, therefore, urine of this description is presented to us, a little acetic acid should first be added; this will restore the transparency by dissolving the phosphates, and we can then have recourse to the usual tests for albumen, namely heat and nitric acid.

Again, albuminous urine may be turbid from a deposit of lithates, and the disappearance of these not perceptible owing to the coagulation of the albumen. Under such circumstances the best plan to be adopted is to place some of the urine in a conical glass vessel for the sediment to subside; we can then pour from it the supernatant fluid and apply the several tests to each.

To discover the proportion of the various natural constituents of the secretion, and the nature of any abnormal ingredients that may be contained in it recourse must be had to a more elaborate process.

77. We have seen that healthy urine is composed of certain organic and inorganic elements, and that in disease it frequently becomes impregnated with others. I propose, therefore, to consider the whole *analytically* under two heads: 1st. *The normal and abnormal ORGANIC ELEMENTS*, and 2dly. *The normal and abnormal INORGANIC ELEMENTS*.

## 1. ORGANIC ELEMENTS.

### (A) *Normal*.

78. *Urea*.—To detect an excess of urea, (34.) Pour a small quantity of the suspected urine into a watch-glass, and gradually add to it an equal volume of nitric acid. Slight

effervescence first takes place and afterwards a crystalline deposit of nitrate of urea. The rapidity of the crystallization being in proportion to the amount of the urea. This operation requires the mixture to be kept at a low temperature.

When it is desirable to know the exact quantity of urea we must adopt one or other of the following processes.

79. I. Dr. Prout recommends us to evaporate the urine to the consistence of a thick syrup and then add to it when cold, concentrated nitric acid until it becomes a crystallized mass of a dark colour. This is then to be repeatedly washed with distilled water and the acid neutralized with a solution of carbonate of potash or soda. The nitrate thus formed must be removed by crystallization, and the supernatant liquor, containing the urea and a portion of the nitrate, made into a paste with powdered charcoal and allowed to remain for a few hours. Distilled water is then to be added to it, to dissolve the urea and nitrate, and the solution, after having been filtered, evaporated to dryness. If the residuum thus obtained is now heated with boiling alcohol, the urea will be dissolved away from the nitrate of potash or soda, and can be obtained from the alcoholic solution almost in a state of purity by evaporation and crystallization.\*

II. Or the nitric acid may be saturated with carbonate of lead, and the alcoholic solution afterwards obtained as above, and heated with sulphuretted hydrogen and animal charcoal to remove any remaining particles of lead and colouring matter. The urea will thus be obtained in a crystallized form, and nearly pure by subsequent solution and evaporation.

III. Evaporate fresh urine in a water bath to about 1-12th or 1-14th of its volume, allow it to cool, and then filter; to the residue of every pint of urine employed, add slowly, with continual agitation, a solution of half an ounce of oxalic acid in twice its weight of hot water, and an abundant buff-coloured precipitate of oxalate of urea will be the result. Collect this on a calico filter, wash it with a cold solution of oxalic acid and separate the mother water by

\* Med. Chir. Trans. vol. viii.

pressure. Then dissolve it in hot water in a large vessel and neutralize the acid by means of chalk; filter the solution so as to remove the oxalate of lime, and digest it with animal charcoal, again filter and evaporate. Brown coloured crystals of urea will then be obtained and can be procured perfectly colourless and inodorous by repeated solution in warm water and digestion with animal charcoal.\*

IV. Evaporate the urine to the consistence of syrup, taking care that the temperature be not raised too high so as to decompose the urea; then for every pint of urine employed add to it about five ounces of alcohol, which will take up the urea, the extractive and colouring matters, and leave the lithic acid and its compounds, together with the various alkaline and earthy salts behind. Separate these by filtration, and wash them with alcohol to remove any remaining portion of urea. Mix the two solutions, evaporate them to a syrupy consistence, and then treat the residue with an equal weight of pure nitric acid, when the nitrate of urea will be formed in such abundance as to constitute a solid crystalline mass, containing an excess of nitric acid, the organic matters, and a portion of the mother water. From these it must be separated by squeezing it in a fine linen cloth, and frequently rinsing it while contained in the latter in ice-cold water. It is then to be compressed between sheets of blotting paper, dried by a gentle heat and weighed. The nitrate of urea thus obtained is slightly coloured and contains a certain portion of organic matter, while the weight of urea present in it may be ascertained from its composition. (Lecanu.)

V. Berzelius's method consists in evaporating the urine to dryness over a water bath and treating the solid mass with alcohol in order to separate those matters soluble in it. The alcoholic solution thus obtained is then submitted to distillation and the yellow residue dissolved in a little water and digested with animal charcoal. The liquor is then filtered, heated to 122 degs. and saturated with oxalic acid; oxalate of urea is formed which becomes deposited in colourless crystals as the solution cools. The mother water must be evaporated, and a fresh portion of oxalic

\* Graham's Chemistry, p. 993.

acid added to it, in order to obtain more crystals of the oxalate of urea. The whole of the crystals are now to be washed in ice-cold water and afterwards dissolved in boiling water mixed with a little animal charcoal. This is then to be separated by filtration, and the liquor saturated with carbonate of lime; effervescence takes place, oxalate of lime is precipitated, and the urea remains in solution from which it is to be procured by evaporation. It may be obtained perfectly free from impurities by repeated solution in pure anhydrous alcohol and distillation.

VI. Mix the urine with basic acetate of lead, and add sufficient sulphuric acid to convert the acetates into sulphates. Then filter the solution through animal charcoal, evaporate it, and tolerably pure crystals of urea will be obtained. (O. Henry).

VII. Ragsky proposes to determine the amount of urea from the products of its decomposition. For this purpose he mixes in a flask one part of urine with three or four of strong sulphuric acid, and raises the temperature of the mixture to *nearly* 572 degs. The urea begins to be decomposed at 383 degs. Carbonic acid gas is disengaged and is evolved in great abundance at 393 degs.. while the ammonia, which is also formed, unites with the sulphuric acid. He then determines the amount of ammonia in the form of the ammonio-chloride of platinum, from which he afterwards calculates the quantity of urea. By this process he found that 4.03 grains of urea yielded 29.8 grains of ammonio-chloride of platinum which corresponds to 4.01 grains of urea; and that 4.84 grains of urea yielded 35.7 grains of the double platinous salt corresponding to 4.81 grains of urea.\*

VIII. Heintz also recommends a similar process. It is as follows: "A weighed quantity of urine, 6.8 grammes, is treated with about thirty drops of muriatic acid, and set aside in a cool place for twenty-four hours, then filtered through a very small filter into a large platinum or porcelain crucible; the filter and glass are washed with a small quantity of water; the filtrate is treated with about six grammes of sulphuric acid, and the liquid evaporated over a small

\* Liebig's and Wöhler's Annalen for October, 1845.



spirit-lamp, taking care that it does not boil, until the evolution of carbonic acid commences. The crucible is then covered with a watch glass and heated until the evolution of carbonic acid ceases, the temperature not being allowed to exceed 180 degs. The contents of the crucible are then filtered into a porcelain dish, the crucible and the watch glass are well washed, and the filtrate is evaporated until almost all the water is passed off. About twenty drops of muriatic acid are then added to the residue, a sufficient quantity of chloride of platinum and alcohol mixed with ether being then added. If the liquid from which the precipitate has subsided is of a very pale colour, more chloride of platinum must be added. After 8.10 hours the precipitate is separated by filtration, washed, dried, and heated to redness in a crucible, which is at first covered, but subsequently open. The residue is treated with boiling dilute muriatic acid, the solution filtered, and this is repeated until the liquid which drops from the filter leaves no residue when evaporated upon platinum-foil; the crucible and filter are dried at a gentle heat; the latter is burnt in the former and weighed. Thus the amount of platinum, which corresponds to that of the potash, ammonia, and urea, is obtained.

Another weighed quantity of the fresh urine is treated once with chloride of platinum, three volumes of alcohol, and one of ether; at the end of ten or twelve hours the mixture is filtered, and the precipitate heated to redness in a well-covered and weighed platinum crucible. The residue is treated as above with dilute muriatic acid, the filter is burned and weighed. We thus obtain the weight of platinum which corresponds to the potash and ammonia contained in the urine; its per-centage is calculated and then deducted from that obtained in the first experiment; the difference gives the amount of platinum which corresponds to the urea.”\*

80. The urea, as we have seen, (34), is also liable to be deficient in quantity, both absolutely and relatively. When there is an absolute deficiency, it may take place in common with a diminution of the other solid constituents of the

\* Chemical Gazette, vol. iv. p.p. 19, 20.



urine, and of the water; or of the solid constituents alone, the amount of water remaining normal. In both these cases the actual decrease can only be ascertained by one or other of the preceding processes, (79). When a deficiency of urea is suspected, it has been recommended to evaporate the urine to about one-half, and then to add to a portion thus concentrated and placed in a watch glass, an equal quantity of strong nitric acid or a saturated solution of oxalic acid; when, if no crystallization takes place, the urea is to be considered as deficient. It is obvious, however, that this method cannot be relied upon; the detection of any deficiency requiring in fact, as Dr. Prout has stated, "a more elaborate process."

81. Should albumen be present in large quantities in the urine it must be previously thrown down by means of alcohol, collected on a filter, and washed with the spirit. The washings are then to be mixed with the alcoholic solution obtained as above directed, and from which the urea is to be procured. M. Heintz's method consists in boiling a carefully weighed portion of the albuminous urine with the bichloride of mercury in a large open dish, collecting the precipitate that is formed on a filter, breaking it up and washing it with water. Then passing a stream of sulphuretted hydrogen slowly through the filtered liquid, and removing from it by filtration, the sulphuret of mercury that is produced. The filtrate is now to be evaporated mixed with sulphuric acid, until the whole of the urea is decomposed, which may be known by the cessation of effervescence as pointed out by Ragsky, and the fluid which remains, treated, as already described (viii.) It now remains to calculate the amount of potash and ammonia. This is done by throwing down the albumen from a second portion of the urine, (also weighed), by means of bichloride of mercury, and heating the filtered fluid with bichloride of platinum and ether, when the quantity of platinum obtained from the precipitate will indicate the proportion of the alkalies. This method is applicable to urine containing blood, milk, or bile, and in the opinion of Heintz, even to Diabetic urine.

Dr. Griffith recommends the alcoholic solution of the residue that is left on evaporating albuminous urine to dry-

ness, to be evaporated, and the extract dissolved in distilled water, the solution then reduced to the consistence of syrup and mixed with half its bulk of pure nitric acid. The formation of crystals of the nitrate having been promoted by placing the mixture in ice, the supernatant liquid is to be poured off, and the crystals then washed in ice-cold water, and subsequently dried in an open steam bath.

81.\* To obtain the urea from Diabetic urine M. Bouchardat proceeds by taking the residue left after the evaporation and crystallization of the urine, and dividing it into several portions, and treating each successively with alcoholated sulphuric ether. He then mixes the several solutions, evaporates them at a gentle heat, and dissolves the residue in a sufficient quantity of water, from which, when filtered, and a few drops of weak nitric acid have been added, he obtains the urea in the form of nitrate.\* Dr. Christison merely evaporates the urine quickly over a steam bath at a temperature of about 200 Farn. to about one-sixth of its volume, then adds to this one-fourth of its amount of pure nitric acid diluted with an equal weight of water, and exposes the mixture to a moderate degree of cold. Some have recommended to previously destroy the sugar by fermentation, but it is doubtful whether the transformation of the urea into carbonate of ammonia is not more likely by this process to be occasioned.

82. Urea may be artificially prepared by well mixing twenty-eight parts of dry ferrocyanuret of potassium with fourteen of peroxide of manganese both in fine powder and heating the mixture, placed on a smooth iron plate to a dull red heat, at which temperature it inflames, and must be kept stirred so as to allow of a free access of air and prevent agglutination. When cold the mass is to be treated by repeated portions of water, and twenty and a half parts of sulphate of ammonia, are to be added to the solution, from which a copious deposit of sulphate of potash then takes place. The supernatant liquor containing the cyanate of ammonia must afterwards be decanted off and evaporated in order to separate still more of the sulphate, and this process repeated until the whole of it is removed, when the last

\* Loc. Cit.

decanted liquor is to be evaporated to dryness, and boiling alcohol of from eighty to ninety per cent added to the residue. This takes up the urea, which is obtained as the solution cools, or by evaporation, in beautiful colourless crystals. One pound of ferrocyanuret of potassium will yield about four ounces of urea.

83. *Lithic Acid.* This is frequently met with in the urine in the form of a crystalline deposit, varying in colour from a light fawn to a deep brown or brownish red, which is owing either to its being in excess (44,45,) and consequently no longer entirely retained in solution, when the fluid cools, by the double phosphate of soda and ammonia, (41,) or to the presence in the secretion of some free acid, (45,) by which the lithate of ammonia becomes decomposed.

84. To ascertain whether a particular deposit be lithic acid, place the urine in a tall conical glass vessel, and when it has stood some time, and the sediment has subsided, decant nearly the whole of the supernatant liquor and pour a small quantity of the turbid remainder, containing the deposit, into a watch glass. Then if uric acid be present it will be known by its remaining undissolved when the urine is heated over a spirit lamp; by being precipitated in combination with ammonia from its solution in liquor potassæ by hydrochlorate of ammonia; by its not being acted on either by hydrochloric or acetic acid; by its being soluble in nitric acid with the disengagement of equal volumes of nitrogen and carbonic acid gases, and also in sulphuric acid from which it is again precipitated by water; by the pink coloured residue (the erythric acid of Brugnatelli,) left after the evaporation of the acid solution, being changed to a beautiful purple when exposed to the vapours of ammonia, owing to the formation of murexid, and lastly by its yielding urea and evolving an odour of prussic acid when burnt, and leaving a white substance composed principally of phosphate of soda and lime.

85. When examined under the microscope uric acid is seen to crystallize in rhomboidal prisms, or in some modification of this form; the particular shape of the crystals appearing to depend on the rapidity of their crystallization, on the quantity of colouring matter contained in them, and on the nature of the precipitating agent. The forms most fre-

quently observed are the rhomboid and the quadrilateral tables, which, in some cases appear nucleated by being marked all round at a short distance from their borders. Occasionally, however, we meet with them of a spindle shape, at other times they appear like so many flattened cylinders which are in reality "thick lozenges lying on their sides," (Bird) and require to be made to roll over, either by agitation or by the addition of a few drops of alcohol, in order that their true shape may be detected. Sometimes, when the urine is very acid for instance, the surface of the quadrilateral tables are either entirely or partially covered with numerous dark straight lines, their extremities, in consequence, having a serrated appearance. In those cases where they are only partially striated, the plane part frequently presents two concentric lines placed with their convexities towards each other. Or the striæ may be so arranged as to leave between them two clear triangular spots united at their apices. When the deposit is of a deep orange or red colour, the crystals are generally found adhering together in clusters having the appearance either of thick rhombic prisms collected together in bundles, or placed across or parallel to each other; or of spinous or striated masses of cohering lozenges.

86. Before examining the deposit it is however always better to previously dissolve the urate of ammonia with which it is frequently combined, by heating the urine and then to remove the latter with a pipette and replace it with a little distilled water.

87. To detect an excess of uric acid (41, 44, 45,) for a deposit is no proof of it, Dr. Bird recommends the whole of the urine voided in twenty-four hours to be collected and well shaken, and about an ounce of it gently warmed and mixed in a conical glass vessel with about half a drachm of hydrochloric acid. By allowing the mixture to stand for six or eight hours, the sides of the glass will become covered with a copious deposit of crystals of uric acid. The urine is now to be poured off and replaced by cold distilled water, and the crystals detached with a feather or a spatula, and collected at the bottom of the vessel. The water is then to be decanted and the acid placed in a watch glass, the weight of which is known, dried and weighed.

This process also enables us to ascertain, by simple multiplication, the actual quantity excreted in the twenty-four hours; but as hippuric acid is obtained at the same time it should be removed by means of boiling alcohol previous to drying the precipitate in order to avoid error in calculation. (51.)

An excess of lithic acid, when it does not constitute a deposit, as is sometimes the case, can also be detected by nitric acid, when added to a high coloured urine, producing a brown precipitate possessed of the preceding chemical and microscopic properties.

88. The amount of lithic acid contained in the urine may also be discovered by proceeding as for urea, viz. by evaporating the secretion to the consistence of syrup, and then treating it with alcohol. This will throw down the uric acid in combination with some of the colouring and animal matters and the alkaline and earthy salts. The supernatant liquor containing the urea and hippuric acid in solution, is then to be poured off and the precipitate washed with alcohol and allowed to dry. Cold hydrochloric acid is afterwards added to dissolve the saline matters and decompose the urates, when the uric acid will be left tolerably pure, and requires only to be dried and weighed.

In having recourse to this test it is necessary that the urine should be perfectly limpid, that is, free from viscosity, for if any mucus for instance, be present it will prevent the uric acid from being precipitated; therefore when it is not so, it had always better be previously filtered.

89. Another mode consists in taking the residue, (composed of lithic acid, and vesical mucus, the extractive and colouring matters, the alkaline and earthy phosphates, and silex,) that is left when alcohol is added to the urine reduced to a syrupy consistence, for the purpose of separating the urea, and washing it with water in order to remove the alkaline salts, then drying and weighing it and afterwards incinerating it in a platinum or porcelain capsule. By this means we get rid of the organic matters, viz. the uric acid and mucus, and obtain as a residue, the earthy phosphates in combination with silex if any be present in the urine. We have now only to weigh this when we at once ascertain the quantity of uric acid and vesical mucus, by the loss



that has been sustained by incineration. The mucus, however, being as we have seen, (64) in such exceedingly minute proportion, may be neglected in the calculation.

90. *Urate of Ammonia*.—Deposits of this substance never occur in the urine in a crystallized form, therefore are not likely to be confounded with uric acid, (85) but generally in an amorphous state, of a yellow, red, pink, or purple colour, and sometimes nearly white. Occasionally, however, they have a ropy appearance, and are dispersed through the fluid like mucus or muco-pus (47a.) They are known by being dissolved on the application of heat and by the addition of a solution of ammonia or potash. The hydrochloric and acetic acid, also dissolve them with decomposition setting free the uric acid which becomes deposited, and may be recognized by its various chemical and microscopic properties above described. (85.)

91. They not unfrequently exist in combination with the lithate of soda and occasionally also with that of lime. When this is the case the deposit is not entirely dissipated by heat, the soda and lime remaining behind as a white ash at the bottom of the capsule, when they may be detected by the usual tests. Thus by adding to their solution in hydrochloric acid a little oxalate of ammonia, the lime if present becomes precipitated as an insoluble oxalate, and the supernatant liquid will yield on evaporation crystals of chloride of sodium (common salt) if it contain soda. Moreover soda gives a rich yellow colour, and lime a dull brown to the flame of a blow-pipe.

92. A positive proof of a deposit consisting of lithate of ammonia is its disappearing when the urine is heated, and its being replaced by crystals of uric acid when a few drops of acetic acid are added to it in a watch-glass. It occasionally happens, as when the lithate is mixed either with the earthy phosphates or with mucus, that the urine does not become perfectly transparent by heat. If this be owing to the presence of the phosphates they will be dissolved by acetic or hydrochloric acid, but if to mucus no such change will take place. In order to avoid error from the latter ingredient, the urine ought always to be filtered before it is warmed. It also sometimes occurs that the urine after it has been rendered clear by being submitted to a gentle heat,



becomes again turbid by the further application of heat. This is owing to the presence of albumen.

93. To determine its quantity, collect the whole of the urine of twenty-four hours, ascertain its specific gravity and divide it into two portions. Evaporate the one in order to obtain the amount of solid constituents, and collect the sediment from the other; mixed, as the case may be, with lithic acid, the earthy phosphates or mucus on a filter, the weight of which is known. Wash it in ice cold water, dry and weigh it, and its proportion to the solid matters and to the urine will be obtained. Then place it in a test tube and boil it with a little of the urine. Afterwards filter it, wash the residue with hot water and stand the clear fluid that passes through in a freezing mixture, to promote the separation of the lithate. When this has taken place it can be collected, dried, and weighed, and its absolute and relative proportion ascertained.

94. The most frequent appearance presented by lithate of ammonia under the microscope is that of very small globules arranged together in rows. Occasionally, however, particularly in albuminous urine, the globules are considerably larger, and distinct, some of them having sharp or obtuse processes attached to them. Both varieties are generally mixed with crystals of uric acid.

95. *Hippuric acid.* I have already alluded to two modes by which hippuric acid may be obtained (87, 88.) Another, that recommended by Liebig, consists in evaporating the urine in a water-bath to the consistence of syrup, then mixing it with hydrochloric acid, and agitating it with its own volume of ether. This will, in all probability, remain enclosed by the fluid like froth, and require to be separated after a short time, by the addition of one-twentieth of its volume of alcohol, which will at the same time remove the froth and cause a separation of the fluid into two layers. The upper layer containing the hippuric acid and urea in solution, must now be removed with a pipette and treated with several small portions of water, in order to wash away the alcohol and urea and leave the hippuric acid dissolved in the ether. By then evaporating the ethereal solution, the acid will be obtained in the crystallized form.\* From this

\* Lancet for June 1, 1844.

statement we should suppose hippuric acid to be soluble in ether, but we have already seen that this is not the case, or at least to a very slight extent only. (84.)

The best method for detecting this acid is to add to the urine, reduced to the consistence of syrup, an excess of hydrochloric acid. By this means the hippuric acid will be thrown down together with the lithic, from which, after some little time, when the supernatant liquor has been poured off, it can be separated by boiling the precipitate in alcohol, in which lithic acid is insoluble. The alcoholic solution thus obtained, will then yield on evaporation, crystals of hippuric acid, to be recognized by their chemical and microscopic characters already described (51.)

96. Dr. Day recommends the following process: "Evaporate the urine till there is a copious deposition of salts. Add strong alcohol and place the mixture in a stoppered bottle. With the aid of a gentle heat (for instance, by placing the bottle in warm water,) we ensure the solution of the urea, the lactates, (if any are present,) and the hippurates in the alcohol, whilst the urates remain with the insoluble constituents. When the supernatant fluid is perfectly clear it must be decanted, evaporated nearly to dryness, and re-dissolved in hot water. If a stream of hot water be passed through the aqueous solution, the urea is destroyed; and, by gradual concentration, and the addition of a little free mineral acid, we obtain crystals of hippuric acid.

97. When an excess of hippuric acid is suspected in the urine, place some of the latter in a large watch-glass, and evaporate it nearly to dryness over a spirit lamp, then add about half its bulk of hydrochloric acid which will cause the mixture to assume a bright pink colour, and give off a powerful odour somewhat similar to that of new hay. Set the mixture aside, and after a few hours, provided the acid is in excess, crystals of a peculiar linear shape will make their appearance." (Bird.)

In order to purify hippuric acid Dr. A. Bensch has recourse to the following process. Having precipitated the acid from the urine by means of hydrochloric acid, he collects it on a strainer, well presses it, and treats it with ten times its weight of boiling water and an excess of milk of

lime. He then filters the mixture, presses the precipitate, treats the fluid with a solution of alum as long as it has any alkaline reaction, allows it to cool to 104 degrees Farnh., saturates with a solution of bi-carbonate of soda, again strains and presses, and lastly adds hydrochloric acid to throw down the hippuric. This is afterwards washed, pressed, and dissolved in boiling water: an ounce of animal charcoal is then added to every pound of the moist acid, and the boiling liquid filtered through paper, when perfectly white hippuric acid will be obtained.\*

(B.) *Abnormal.*

a. *Crystalline.*

98. *Uric or Xanthic Oxide*, (66,) has been but very rarely met with. It has a great resemblance to uric acid which is very liable to be mistaken for it. When, therefore, its presence is suspected in a deposit, Dr. Bird recommends the latter to be treated with a weak solution of carbonate of potash, which will separate the uric acid and leave the oxide undissolved. The principal features by which it is distinguished are the fleshy colour of its external surface; the brownish-red, or cinnamon hue it presents when broken; the waxy appearance it assumes on being rubbed, and also its different actions towards various reagents. Thus it dissolves *but slowly* in nitric acid and *without* effervescence, and leaves a *yellow*, not a *pink* residue like uric acid (36,) on the evaporation of the acid solution. It is not precipitated by water from its solution in strong sulphuric acid, nor from its solution in liquor potassæ by hydrochlorate of ammonia. It is insoluble in a solution of carbonate of potash and yields no urea or bitter almond odour like lithic acid when burnt. When examined under the microscope it has not been found to have any distinct crystalline form, even when precipitated from its solution in liquor potassæ.

99. *Oxalate of Lime*, (66.) Crystalline deposits of this substance were formerly supposed to be of exceedingly rare occurrence, but this has been entirely disproved by the late

\* Chem. Gaz. for Nov. 16, 1846.

researches of Dr. Bird,\* who, from his experience, is led to the conviction that “in the cases of disease occurring in the metropolis, the *oxalate is of far more frequent occurrence in the urine* than the deposits of earthy phosphates,” an opinion which is fully corroborated by Dr. Shearman of Rotherham, who states as the result of his observation, that, next to the urates, small quantities of the oxalate are most commonly met with in the secretion.†

It appears to be intimately connected with that particular state of the system characterized by great nervous irritability. The urine in these cases has its natural amber colour, but is generally somewhat darker than in health, and has only been met with by Dr. Bird of the citron yellow or greenish hue described by Dr. Prout as being peculiar to the oxalic acid diathesis, when blood corpuscles have been present in the secretion. It is likewise acid in the great majority of instances, and subject to very great variation in its specific gravity. Thus it has been observed by Dr. Bird as low as 1.009 and as high as 1.030. “*It increases with the quantity of urea,*” of which the urine, generally in these cases, contains an excess, sometimes even to a very considerable extent, so that crystallization takes place immediately nitric acid is added; the abundance and size of the crystals of the oxalate appearing also to be in a direct ratio with its amount. It may, however, be said to range generally speaking, between 1.015 and 1.025.

I have already alluded (66) to the various sources to which the existence of oxalate of lime in the urine is to be ascribed, namely, slight deoxidation of the elements of urea and water, oxidation of uric acid, certain articles of food, and the mal-assimilation of saccharine matters. With reference to the last, and considering the great importance of the subject, the following interesting remarks may with considerable advantage be quoted from our great authority on Oxaluria, Dr. Bird. “It is scarcely possible,” says he‡ “to avoid being impressed with the very probable physiological relation between oxalic acid and sugar: we know that the

\* See Med. Gaz. for 1842.

† Urinary Deposits, p. 165.

‡ Loc. Cit. p. 175.

latter substance forms a considerable item in our list of aliments; we know that the great majority of farinaceous matters are partially converted into this element during the act of digestion.\* It is indisputable that, under certain circumstances, it finds its way into the blood, and is eliminated by the kidneys; even when artificially introduced it is thus thrown out of the system. I have in my possession fine crystals of sugar prepared by my friend, Dr. Percy of Birmingham, from the urine of a dog, into whose veins he had previously injected a solution of that substance. Lastly, we know that, under certain morbid influences, the great proportion of our food may, whilst in the stomach, become converted into sugar, which becoming absorbed, rapidly passes through the circulation, and is thrown out of the system by the kidneys as an effete matter, with the effect of producing more or less rapid emaciation, and in most cases leading to fatal marasmus. Dr. Aldridge† of Dublin, has even lately suggested the probability of a substance analogous to sugar, [59] capable of undergoing acetous fermentation, being a normal element of the urine. Then, recollecting the facility with which sugar and its chemical allies, as starch, gum, and wood fibre, are, under the influence of oxydizing agents, converted into oxalic acid, and having sufficient amount of evidence to prove that when oxalic acid is really found in the urine, symptoms bearing no distant relation to those of a diabetic character are met with, we are almost inevitably led to draw the induction that the oxalate of lime found in the secretion owes its origin to sugar, and to locate the *fons et origo mali* in the digestive organs. This appears to be nearly the view adopted by that very excellent authority in these matters, Dr. Prout." And he goes on to state that his experience has led him "to the following conclusions regarding the circumstances under which the oxalate of lime occurs in the urine.

I. That in the urine under examination oxalate of lime is present, diffused through a fluid, and in a crystalline form.

\* Gmelin and Tiedemann, *Recherches expérimentales sur la Digestion*.—Paris, 1827, p. 202. [Also Papers, by the Author, in the *Med. Times* vol.xv. from the French of M. Bouchardat relative to this subject.]

† Lectures on Urine.



II. That in rather more than one-third of the cases, uric acid or urates existed in large excess, forming the greater bulk of the existing deposit.

III. That in all, there exists a greater proportion of urea than in natural and healthy urine of the same density; and in nearly 30 per cent of the cases so large a quantity of urea was present, that the fluid crystallized into a nearly solid mass on the addition of nitric acid.

IV. That the urate of ammonia found in the deposits of oxalic urine is occasionally tinted of a pink hue.

V. That an excess of phosphates frequently accompanies the oxalate.

VI. That the existence of free sugar in the specimens I have examined, is the exception to the rule."

100. Deposits of oxalate of lime, independent of numerous epithelial scales with which they are almost always found combined, generally occur alone in the urine. They have, however, been sometimes found mixed with lithic acid and lithate of ammonia, and occasionally with the triple phosphate.

101. In order to detect the presence of this salt in the urine, a portion of the latter, passed a few hours after a meal, is recommended by Dr. Bird to be set aside in a tall glass vessel for a short time, the upper 67-ths then poured off and a little of the remainder placed in a watch glass and gently heated over a spirit lamp so as to dissolve any urate of ammonia that may have become deposited (a circumstance of frequent occurrence in winter,) and to promote the subsidence of the crystals of the oxalate, which have the very remarkably tendency to remain diffused through the urine, even when present in it in considerable quantity. By then giving the fluid a slight rotatory motion, they will be collected together at the bottom of the capsule. The urine is now to be almost entirely removed from them with a pipette and replaced with a little distilled water, when a white, often brilliant powder will make its appearance, which with the aid of a microscope, furnished with a half-inch object glass, will be seen to consist of transparent, well defined, octahedral crystals of oxalate of lime. Examined when dry, they are found to have a quadrilateral shape, and appear to be composed of two squares, one



within the other, the central one being transparent and the outer one dark, and so arranged that the sides of the former correspond to the angles of the latter. Sometimes they are somewhat of a dumb-bell shape, or resemble that presented by two kidneys united together at their fissures.

102. Deposits of oxalate of lime may also be recognized by their solubility in the nitric and hydrochloric acids; by their remaining undissolved when boiled in liquor potassæ or acetic acid; by yielding on incineration first carbonate of lime and afterwards the oxide of the metal, and by their being decomposed when boiled in a solution of carbonate of potash, with the formation of carbonate of lime and oxalate of potash; the former being precipitated while the latter remains in solution.

108. *Cystic oxide or Cystine*, (66), constitutes rather a rare deposit. In the opinions of Drs. Prout and Bird, it is to be met with in the urine more frequently than has been imagined. When present in the urine, the latter is always turbid when passed, and lets fall a very abundant sediment. It is of a pale or greenish-yellow, or honey colour, and generally somewhat reduced in specific gravity. When fresh, it has, in the greater number of cases, no reaction on test paper, occasionally, however, it is acid, and if kept, soon becomes alkaline. Its odour on emission resembles that of sweet-briar, and assumes a peculiar fœtid character when putrefaction takes place, owing probably to the disengagement of sulphuretted hydrogen. On standing it also becomes coated with a gray looking pellicle, which has been found to consist of crystals of the substance under examination and the triple phosphate.

104. Deposits of cystine are characterized by the following properties. They are of a pale or light fawn colour; are not affected by heating the urine; are insoluble in alcohol; but slowly dissolved by nitric or hydrochloric acid, which readily distinguish them from the lithates (90) and phosphates, (153 to 156), are decomposed by an excess of the former, a brown residue being left. They are also soluble in the sulphuric, phosphoric, and acetic acids, in solutions of the volatile and of the fixed alkalies, and also of the carbonates of the latter, but not in the carbonate of ammonia or in the vegetable acids. When burnt they give

a greenish blue tint to the flame, and emit a disagreeable acid but characteristic odour.

105. To examine the microscopical characters of cystine, first remove any lithate of ammonia that may be present by boiling the sediment in water, and afterwards dissolve the oxide in a little liquor ammoniæ, and allow the ammoniacal solution to slowly evaporate on a slip of glass; then place this under the field of the microscope, and crystals will be observed, either of a well-defined hexagono-laminated shape, perfectly transparent or with opaque centres; or in round masses, dark in the centre, with serrated or notched borders resembling rosettes, and numerous markings on their surface, an appearance which seems to be due to several plates having become placed one above the other. Or the compound deposit, consisting of a mixture of cystine with either the urates or the phosphates, may be treated at the onset with a little liquor ammoniæ, the cystic solution then evaporated, and the residue examined under the microscope.

#### b. Organized.

106. Blood.—The presence of blood in the urine is owing, as we have seen, (66a), to very various causes, and is sometimes so abundant as to give it a dark red, or port-wine, or even black appearance; while in others it exists in such a minute proportion as to be almost imperceptible. Its existence in large quantities in the urine may be suspected from the dark colour just alluded to of the latter; from the large black masses resembling coagula, contained in the secretion; and, together with these, from the alkaline reaction of the urine on test paper. In those cases where the blood is less abundant, the urine instead of assuming the dark colour above-mentioned, has a dirty aspect, is without coagula, and lets fall a reddish sediment.

107. When urine, contaminated with blood, is boiled, it becomes turbid, owing to the coagulation of the albumen, and changed to a dirty brown colour, and, when nitric acid is added to it, deposits an albuminous precipitate, more or less copious in proportion to the quantity of blood present in it.

108. To detect its presence, one or other of the following processes may be resorted to:

I. Boil the urine, previously saturated with nitric acid, if it be alkaline, collect the coagulum that is formed, on a filter and treat it with alcohol, acidulated with sulphuric acid in order to remove its colouring principle. Evaporate the brown coloured liquid thus obtained, and which is changed to a bright red on the addition of ammonia, and the colouring matter will collect on the surface as a black resinous looking mass, soluble in acetic ether and ammoniated alcohol. To the latter fluid it communicates a red colour, which is converted to a yellow by hydrochloric acid; a blue precipitate being also subsequently formed when ferrocyanate of potash is added to the yellow solution, (Lecanu).

II. Boil the urine, collect the coagula on a filter, and pour over them liquor potassæ; add hydrochloric acid to the greenish fluid that passes through, and white coagula consisting of protein will be formed (Pariset *Journal de Chimie*, 1840, p. 68.)

109. The most speedy and certain mode, however, of ascertaining the presence of blood in the urine is by means of the microscope. Place a little of the suspected dark coloured urine in a watch glass under the field of this instrument, and if blood be present it will be detected by its characteristic corpuscles, which are more or less altered in shape in proportion to the length of time they have been acted on by the secretion. They are generally distinct and appear flatter than natural, owing to exosmosis, and have sometimes fringed or serrated borders. Occasionally, when the urine is examined very shortly after its admixture with blood, they are met with in their normal condition, namely, as flattened vesicles with bright central spots adhering together in rouleaux.

When the quantity of blood is so small as to scarcely tinge the urine, then a portion of the coloured deposit which mostly subsides, or of the lowermost stratum of the fluid must be examined. It sometimes happens, however, that in these cases the blood corpuscles have become dissolved, and then the microscope is of no avail. Our only resource then left is to ascertain if the fluid becomes coagulated or opaque, and if its colour disappears by boiling.

Having detected the presence of blood it becomes highly

necessary to discover from what part of the urinary apparatus it has arisen, whether from the kidneys, the ureters, the bladder, or the urethra. This is not at all times an easy matter and requires several circumstances to be considered before we can arrive at just and true conclusions.

110. When it proceeds from the kidneys, there will generally be some symptoms referrible to these organs, caused either by an injury to the loins or by some morbid condition of the glands themselves, as inflammation or congestion, or tubercular or cancerous degeneration, or by the presence of a calculus. The urine, moreover, will be tolerably uniform in colour, and when the blood is very abundant, will contain dark elongated coagula. This is more particularly the case when the hæmorrhage has been occasioned by a violent blow, or by a penetrating wound in the lumbar region, or by the presence of a stone.

111. When it proceeds from the ureters, it is almost always produced by a calculus, which may be readily detected by the symptoms it gives rise to, namely: sudden and severe, but intermitting pain, extending round the loins downwards towards the testicles, rendering these spasmodically painful and forcibly retracted, and giving rise to distressing nausea, vomiting and even faintness.

112. If it proceeds from the bladder it may generally be readily discovered by the accompanying symptoms being principally referred to this viscus; the kidneys and ureters remaining unaffected. The symptoms however will vary considerably, according to the cause which has given rise to them, (See Tabular view,) and in some cases, indeed, will be entirely wanting, as when the hæmorrhage is vicarious to some periodical discharge of blood, such as the menses, and in some cases hæmorrhoidal flux, &c.

113. If the urethra be the seat of the hæmorrhage, it will be easily detected by the escape of pure blood, free from urine, both previous to and after the evacuation of the bladder, and by the first portion of urine passed being slightly tinged, while the remainder is perfectly clear and of its natural colour. There are likewise no symptoms referrible, either to the bladder or the kidneys. It sometimes happens, however, that the blood has passed backwards into the bladder; in that case the whole of the urine will be

coloured in proportion to the quantity of blood that has retrograded. The true seat of the hæmorrhage may, nevertheless, be generally detected by the accompanying symptoms.

114. *Pus* (66*b*). Urine containing pus is always more or less turbid when passed. On standing, it becomes somewhat clearer, but never perfectly transparent. This is owing to the subsidence of the purulent matter, which then has the appearance of a thick sediment of a pale yellowish-green, or dirty white colour, and is easily disturbed by the slightest motion of the fluid. The urine is mostly acid or neutral when voided, and but slowly undergoes decomposition. The ammonia, however, which is formed when this change does take place, not only renders the secretion alkaline, but also completely alters the nature of the deposit by making it tenacious and viscid.

115. To ascertain whether a sediment consists of pus, pour from it the clear supernatant fluid, and test it for albumen with heat and nitric acid; then collect the suspected deposit and add to a part of it an equal volume of liquor potassæ, and to another portion some ether, and place the remainder under the field of the microscope. Then, if coagulation or an opacity takes place in the first; gelatinization or coagulation in the second; and yellow fat globules are left by the evaporation of the third; while, in the fourth, granular and opaque globules are observed floating in an albuminous fluid—the *liquor puris*—we have positive proof of the purulent nature of the morbid deposit.

116. Pus globules are distinguished from blood corpuscles or discs (109) by being larger, granulated, and less transparent, and by their external membrane becoming dissolved, and the nuclei which they contain, thereby rendered distinctly visible, when acetic acid is added to them.

117. Purulent deposits are liable to be mistaken for mucus or the phosphates. The former may be diagnosticated by its characteristic features, (119) while the phosphates may be known by their being dissolved by an acid.

118. *Mucus* (66*c*).—Urine containing mucus in excess is always more or less turbid, and frequently is so consistent and viscid as to have the appearance of a gelatinous mass. It is remarkably prone to decomposition, the mucus in all



probability acting as a ferment (29), and has, when this takes place, a remarkably fœtid, disagreeable odour, and an alkaline re-action on test paper. If the decomposition commence previous to its excretion, it then acquires irritating qualities, and by acting on the lining membrane of the bladder, causes an increased formation of mucus. The mucus therefore must be considered as both the *cause* and *effect* of the putrefactive change which the urinary secretion undergoes. Mucus, when present in the urine in large quantities, always falls in great part to the bottom of the vessel in which the secretion is placed, from which it rises, when the fluid is shaken, in large stringy or ropy masses.

119. The characteristic features of a mucous deposit, and those which distinguish it from pus, are its ropy or stringy appearance; its not perfectly separating from the urine as a homogeneous yellowish substance, but always remaining somewhat suspended in it in the form of long stringy masses; its being coagulated by acetic acid; its yielding very few, if any, fat globules to ether, and its not rendering the urine albuminous. Another distinguishing feature between mucous and purulent urine is that the former is alkaline and the latter mostly acid or neutral; the one being prone to putrefaction while the other undergoes that change but very slowly.

120. The microscopic characters of mucus are much the same as those of pus, and therefore are of no avail in diagnosis.

121. It not unfrequently happens that both pus and mucus are contained in the urine at the same time. In that case the secretion will present more or less of the characteristic appearances above described as peculiar to each substance. The whitish ropy deposit of lithate of ammonia (90,) is liable to be mistaken for the sediment occurring under these circumstances. It may, however, be distinguished by disappearing when the urine is heated.

122. Urine voided in an alkaline state may be owing, (and I have had frequent opportunities of verifying the fact) to its having undergone some change or decomposition in the bladder in consequence of some inorbid or inflammatory condition of this viscus, either originating in it or the result of some derangement of the parts anterior to it, as stricture



of the urethra, for instance, and enlarged prostate ; or to its having been secreted in that state, and constituting then, according to Rayer, a symptom of chronic nephritis.

It is of the utmost importance, therefore, to distinguish between these two classes of cases, and the only way of doing so is to draw off the urine, then to wash out the bladder, and examine the fluid that is next secreted.

123. Besides the pus and mucus globules already described, the urine occasionally contains others for which Dr. Bird has proposed the name of ORGANIC GLOBULES. They are of two kinds, the *large* and *small*. The former differ from the pus and mucus particles only in the fluid in which they float not possessing the albuminous properties of the Liquor Puris or the viscid or glairy nature of the Liquor Muci. They seldom constitute an actual deposit but are generally diffused through the urine. They are met with in cases of ardor urinæ, and in the latter months of pregnancy, but are most numerous in confirmed cases of Bright's disease.

The SMALL ORGANIC GLOBULES are of more rare occurrence. They differ from the larger ones, in always forming a distinct deposit, in having a smooth non-granular surface, and in being devoid, to all appearance, of nuclei.

124. EPITHELIUM SCALES may be recognized by their flattened cellulo-nucleated aspect under the microscope. They are occasionally met with in very large quantities, especially during the occurrence of the oxalate of lime deposits. Dr. Johnson has lately discovered fat globules in them, an appearance which, in his opinion, is characteristic of Bright's disease.

125. *Spermatozoæ* (66.) The only way to detect the existence of these animalcules is to submit to microscopic examination a few drops of the lowest stratum of the suspected urine, or a little of the deposit that may have formed, when they will be observed as small oblong bodies with delicate tapering tails.

126. *Torulæ* (66,) are only met with in saccharine urine, while it is undergoing the alcoholic fermentation. Their true nature can only be detected with the microscope. When first examined with this instrument, they are found to consist of small oval vesicles containing in their interior

minute granular corpuscles. At length, by the gradual increase in size of these granules, the vesicles expand, become tubular, and finally put forth small granular, bud-like projections, which enlarge and undergo the same change as their parent cells, so that the fungoid, or confervoid vegetation has then a beaded or jointed appearance, and constitutes a thin pellicle on the surface of the fluid. Occasionally, however, these fungi appear to increase in a different manner, namely, by the bursting of the parent vesicles and the escape of the contained granular bodies, which eventually form themselves into fresh cells.

When the vesicles have remained on the surface united together in the manner above described, for some little time, they separate and fall to the bottom in their original distinct state.

127. *Vibriones*, (66,) have been met with in the pale, light urine of cachectic and debilitated persons. They are excessively small linear bodies, having an oscillating motion, but without any distinguishable organization.

#### *g. Non-Organized.*

129. *Albumen*, (66,) is by no means an unfrequent abnormal ingredient in urine, and in some cases is present in it in great abundance.

It admits, generally speaking, of easy detection. The principal tests are heat, nitric acid, and the ferrocyanide of potassium with the addition of a few drops of acetic acid. The appearances presented by the urine after the application of these tests will be a good criterion of the quantity of albumen present in it, as in some cases it is merely rendered a little turbid, while in others it becomes almost a solid mass.

129. If heat occasion an opacity or a deposit, we must not be too hasty in attributing it to the presence of albumen, as it may be owing to the precipitation of the phosphates. This, however, may be readily discovered if the precipitate is dissolved by the addition of a few drops of nitric acid.

Dr. Griffith, however, has stated in a communication to the Medical Gazette for Oct. 21, 1842, that the albumen, when in small quantity, may also be dissolved by a few

drops of this acid ; but that there is this difference between the two substances, that the latter (albumen) is *precipitated*, while the phosphates *remain* dissolved when the acid is added in excess.

130. If the urine be alkaline no coagulation or opacity may take place. Nitric acid must be used in this case either alone, or what is better, in combination with heat.

131. If nitric acid *alone* renders the urine turbid, ascertain whether the patient has been taking copaiba or cubebs ; for according to Dr. G. O. Rees, such an effect is liable to be the result of the administration of these medicines. This statement has been confirmed by Simon, who states that the precipitate consists of small oil vesicles. No turbidity or deposit is produced in these cases by heat.

It will be seen, therefore, by the preceding remarks, that the effects of both heat and nitric acid require investigation before they can be received as evidence of the presence of albumen, and in fact that each test necessitates the confirmation of the other.

132. To ascertain the amount of albumen it must be precipitated by boiling a given weight of urine then collected on a filter, dried, and weighed, and the quantity contained in the whole of the urine voided in twenty-four hours, calculated from that obtained from the portion examined. Or we may adopt the process recommended by Heller,\* which is as follows : Take a given quantity of urine, say from ten to twenty grains, and determine the percentage of solid matters contained in it ; then rapidly raise another portion of equal weight to the boiling point in a small narrow-mouthed flask. Set this by with its mouth closed, and when the fluid is cold, filter it through a tolerably fine linen cloth, and the albumen will collect upon it. If the addition of nitric acid causes no further precipitation of albumen we may be sure that the whole has been separated. The difference between the amount of solid residue left by the strained fluid on evaporation, and that from the first specimen examined, will represent the quantity of albumen.

\* Quoted by Dr. Day in Simon's Chemistry, from vol. i. p. 192, of the *Archiv für phys. und Patholog. Chemie und Mikroskopie*.

133. "There is a class of cases," says Vogel in his *Erläuterungstafeln zur Pathologischen Histologie*,\* in which the urine—sometimes bloody, sometimes of its natural colour, but always turbid at the commencement—when allowed to remain at rest, lets fall a yellowish white sediment, whereby it becomes clear and transparent. This sediment is not mucous; on agitation it readily mixes with the urine, whereby this latter is rendered turbid for the time, but becomes clear again, as soon as the precipitate is again deposited. The urine sometimes contains a large quantity of albumen, which coagulates on boiling; at other times it contains but little, rarely none at all. Under the microscope this sediment appears to consist of colourless coagula, of a cylindrical form, the diameter and shape of which correspond exactly to the tubuli uriniferi of the kidneys. Like the uriniferous tubules of healthy kidneys they contain, inclosed within them, portions of epithelium, and now and then, rusty coloured granules (altered blood.) These coagula readily dissolve in caustic potash, with difficulty in acetic acid; but by this latter re-agent the epithelial cells contained within the coagula are rendered very distinct.

There seems hardly a doubt that these cylindrical masses are fibrinous coagula, which are formed in the uriniferous tubes, and that during their coagulations portions of the epithelium of these tubes become entangled within them, and the whole substance is then discharged together with the urine, from which the several masses are afterwards precipitated, still preserving the shape of the canals in which they were formed. They vary in length, often measuring several lines: their transverse diameter corresponds with that of the tubules, varying from  $\frac{1}{90}$  to  $\frac{1}{200}$  of a line. Moreover, there are sometimes a large quantity of pus corpuscles present in these cylindrical masses; probably in those cases in which the inflammation has extended to the pelvis of the kidneys and to the ureter."

Dr. George Johnson, of King's College, also states that oil globules, or epithelial cells containing fatty matter, are likewise frequently met with adhering to these tubular fibrinous masses, and that he considers them, when in large

\* Translated by Mr. Kirkes in the Medical Gazette, for May 2, 1845.

numbers, an alarming symptom of Bright's disease, of which they are, in his opinion, pathognomonic.

134. *Bile* (66,) when present in the urine, communicates to it an unnatural tint varying from that of a saffron-yellow to a dark brown, similar to that produced by blood.

135. It may be detected by the following processes:—

i. Dip a piece of clean linen in the suspected urine, and if bile be present it will be changed to a yellow colour, which will be converted to a green by hydrochloric acid.

ii. Pour a little of the urine on any flat white surface, as the bottom of a plate for instance, and gradually add to it a few drops of nitric acid. A rapid display of colours will be exhibited, in which the green, blue, violet, pink, and red will be observed.

iii. Add basic acetate of lead to the urine, and a yellowish precipitate, soluble, with the production of a green colour, in alcohol acidulated with sulphuric acid, will be thrown down. (Schwertfeger in Day's Simon's Chemistry.)

iv. Gradually add to a little of the urine, previously deprived of any admixture of albumen, contained in the test tube, two-thirds of its volume of sulphuric acid perfectly free from sulphurous acid, and then shake the mixture, kept below 144 degrees, with two or three drops of a solution of cane sugar, made in the proportion of five parts of water to one of sugar, when a more or less distinct violet-red colour, in proportion to the amount of bile present in the secretion, will make its appearance. (Pettenkofer.)

This test, however, cannot be safely relied on, owing to the action of the sulphuric acid on the sugar employed.

v. Treat the urine, previously deprived by filtration of the mucus and lithic acid that may have become deposited, with chloride of barium; collect the precipitate that is formed on a filter, and wash it with distilled water. Then boil it in water with carbonate of soda, and separate the biliary colouring matter from the yellow solution thus obtained, by hydrochloric acid. Collect it on a filter, dissolve it in a mixture of two parts of alcohol and one of ether, and evaporate the resulting green solution, when the colouring matter will be left in the form of a dark green mass. Or the barytes precipitate above alluded to, may be at once decomposed by digesting it with alcohol and hydrochloric



acid at a moderate heat, the alcoholic solution then evaporated and the residue washed with distilled water, and afterwards dissolved in the alcoholic ethereal mixture and again evaporated. (Scherer *Ann. der Chimie und Pharm.*, March 1845. *Lancet*, May 24, 1845.)

When dried, this colouring matter may be reduced to a powder, which has a very beautiful dark green colour. It is very sparingly soluble in water and ether, but very soluble in alcohol and liquor potassæ, to the latter of which it communicates a brownish hue. Hydrochloric acid converts it to a blackish brown.

vi. Add the white of an egg, or any other albuminous fluid to the suspected urine, and afterwards separate it by means of nitric acid. If bile be present in the secretion, the coagulated albumen will have a blueish, or perfectly blue or greenish colour. But if there be no biliary matter, the precipitate will be white, being gradually, however, tinged yellow by nitric acid. (Heller.) This test is stated by its author to be extremely delicate, the most minute quantity of bile being detected by it; a thing impossible with nitric acid alone.

136. The colouring matter of bile has been found by Heller to suffer considerable modification in certain diseases, particularly cholera, and in this state not to give its characteristic reaction with nitric acid, a red instead of a green colour, being in fact produced when this acid is added. In these cases he considers ammonia to be the best test. It is to be dropped into the suspected urine in small quantity, when, if bile be present, a bright red colour, which passes to a brownish red on the addition of more ammonia, will be produced.\*

137. If MILK (66*f.*) be present in the urine, the latter will let fall a precipitate consisting of casein, when acetic acid is added to it, and will exhibit fat globules when examined under the microscope.

138. KIESTIEN, (66*g.*)—This substance is principally met with in the urine of pregnant women, in the form of a greasy fat-like pellicle, which, after having remained stationary for three or four days, breaks up and gradually falls

\* *Med. Gaz.* October 17th, 1845.



to the bottom of the cylindrical vessel in which the urine has been placed. It has been supposed to consist principally of casein owing to its occurring in combination with butyric acid. M. Regnault is of a different opinion. According to him it is composed only of very minute microscopic animalculæ and phosphatic crystals, and therefore he considers that the deposit under consideration is not due to the spontaneous coagulation of a substance primitively existing in the urine, but rather to the decomposition of a nitrogenized matter secreted by the kidneys in excess during gestation, which by acting as a ferment in the urine, promotes the conversion of urea into carbonate of ammonia and occasions the peculiar appearance presented by the secretion in these cases.\*

139. According to Dr. Golding Bird, its formation is prevented by an inflammatory state of the system, a statement which has lately been corroborated by M. Möller,†

Suppressed perspiration has also been stated by Dr. Bird to be a cause of the non-appearance of this peculiar pellicle. This, however, does not appear always to be the case, M. Möller having met with an instance to the contrary in a young female in the eighth month of her pregnancy, who, from long continued mental emotion, had become attacked with severe hectic and profuse sweats, without there being apparently any local affection present which could have given rise to them. In this patient's urine not a trace of kiestien could be detected during the whole of the febrile attack, but the moment the hectic disappeared it was found to exist in it in large quantities.

140. Lehmann treated it with ether, evaporated the solution obtained, and procured a fatty matter resembling butter, which yielded butyric acid on the addition of sulphuric acid after being saponified with potash; and Dr. Rees informs us in the last edition of his work, that he has discovered in it globules exactly similar to the fat globules contained in milk. Möller, after he had evaporated the ethereal solution at a gentle temperature, removed the phosphates by means of diluted hydrochloric acid, neutralized any excess of the

\* Med. Times, vol. xvi. p. 176.

† See Med. Gaz. June 5, 1846.

latter with ammonia, and expelled any remaining portion by the application of a moderate heat, procured it in a pulverulent form, without taste or odour, and of a whitish or yellowish colour, insoluble either in alcohol, ether, or water. Urine from which pellicles of kiestien have formed appears to contain no albumen, and but very rarely casein. It is generally neutral or alkaline and occasionally acid; while the pellicle itself is stated never to become mouldy.

141. *Fatty matter*, (66*h*,) occasionally met with in the urine, may also be detected with the microscope, by its characteristic globules; and likewise by the yellow solution that collects on the surface of the urine when ether is added to it, and which yields fat globules on evaporation.

142. *Urostealith*.—This is the name given by Dr. F. Heller, to a peculiar concretion that was passed by a patient while suffering from symptoms of calculus in the bladder, and which he found to consist of a particular kind of fatty matter. These concretions, when first passed are soft, but become hard by drying. They are then brittle, have somewhat the appearance of wax, and a greenish yellow hue when viewed by transmitted light. When heated they melt, then swell and burn with a characteristic pungent odour, something like that of gum benzoin, leaving an abundant ash. Urostealith is soluble in ether, from which it can be obtained by evaporation, but is insoluble in water, and nearly so in alcohol. It is also soluble in nitric acid with effervescence, a colourless substance being formed; and combines readily with alkalies, which will separate it from its ethereal solution.

143. *Sugar*, (66*i.k.*)—The presence of saccharine matter in the urine constitutes diabetes mellitus, an interesting disease characterized by the excretion of an extremely limpid urine “of a pale greenish straw colour, of a peculiar odour deprived of the urinous character; sometimes resembling that of whey, of a sweet taste, of considerable specific gravity and generally acid;” and which, “when left standing by itself in the vessel for some time, becomes somewhat turbid, loses its greenish tint, and undergoes spontaneously the alcoholic fermentation, if the weather be hot.”\*

\* Bell's Essay, by the Author, p. 12.

144. Sugar may generally be detected by the sweet taste it gives to the secretion; occasionally, however, this is completely masked by the other constituents of the urine. (Bouchardat.)

The following are the various tests that have been proposed for it.

I. "The most convenient means of ascertaining the presence of saccharine matter in diabetic urine, is to add to it some yeast, which gives rise to vinous fermentation, a most delicate test, as it can detect one part of it in a thousand parts of urine.\* Every cubic inch of gas given off nearly corresponds in round numbers with one grain of sugar—forty-seven of gas to forty-five of sugar."† The amount of gas may also be ascertained by the increased weight of Liebig's bulb apparatus.

In healthy urine no change takes place on the addition of yeast, with the exception of the disengagement of a *small quantity* of carbonic acid necessarily present in the latter.

II. Another equally delicate test is the growth of *Torulæ*. These spores or fungoid vegetations make their appearance in the urine whenever saccharine matter is present in it in however minute proportions. They may be recognized by their peculiar characters. (126.)

III. Add a few drops of a solution of copper to the supposed diabetic urine contained in a test tube. Slight opacity will take place owing to the formation of phosphate of copper which is precipitated. Then add an excess of *liquor potassæ* and a deposit of the hydrated oxide of copper will be formed, which will be re-dissolved by an excess of the alkali if sugar be present, with the production of a blue solution similar to that of the ammoniuret of copper. By gently raising the mixture to a boiling point, the copper will be deposited as a red suboxide if it contain any saccharine matter, and as a black oxide if it does not. (Fronmer.)

Dr. Bird evidently gives the preference to this test, as being the most delicate of all those hitherto proposed for the detection of sugar in the urine, and in fact, one which "will readily detect it in diabetic urine, even when very largely

\* Christison's Lib. Pract. Med. vol. iv. 249.

† Bell's Essay, p. 16.

diluted, provided "no more of the solution of sulphate of copper be used than is sufficient to afford a decided precipitate on the addition of the *liquor potassæ*."\*

iv. Add to the suspected urine, contained in a conical glass vessel, a small quantity of the hydrated oxide of copper, and an excess of *liquor potassæ*. The fluid, if it contain sugar, will then become of a reddish colour, and the deposited oxide will gradually assume a yellow hue. (Capezzuoli.)

v. Evaporate a little of the urine at a gentle heat in a shallow porcelain dish, and drop upon the dry warm residue a few drops of sulphuric acid diluted with six parts of water, when, if it contain sugar, it will assume a dark brown, or even black colour. (Runge.)

This test, it is said, will detect as much as one part in two thousand; but as similar results will be obtained, according to Dr. Bird, if albumen be present, this must be previously removed before it is had recourse to.

vi. Treat the urine, reduced to the consistence of syrup, with alcohol, and add to the solution obtained a little of an alcoholic solution of potash. A white precipitate, if saccharine matter be present, will then be formed, consisting of a compound of sugar and potash. Wash it in alcohol and dissolve in water; a saccharine solution will thus be obtained, from which the amount of sugar may be determined. (Lowig, quoted in the *Lancet* for Sept. 6, 1845, from part 2, vol. 38, of *Buchner's Repert.*)

vii. Boil the suspected urine in a test tube with an excess of *liquor potassæ*, and if it contain sugar it will assume an orange-yellow, or brown, or claret colour, in proportion to the quantity present, owing to the conversion of the diabetic saccharine matter into melassic acid. (Moore.)

Heller, who seems to have recommended this test about the same time as Mr. Moore, (see *Archiv für phys. und Path. Chem. und Mikrosk.*, 1844, 2 S. 212), states that "if an excess of nitric acid be now added, a strong odour will be developed by the sugar. If a drop of diabetic urine be diluted with ten drops, or even more of water, the presence of sugar will be shown by the above test."†

\* Med. Gaz. for May 24, 1844.

† Quoted in *Pharmaceutical Journal*, vol. v. p. 188.

In having recourse to this test we must be careful that the liquor potassæ contains no lead, (which it may do if it has been kept in a white glass bottle) and the urine no albumen, otherwise, the sulphur contained in the latter, by acting on the lead would produce a sulphuret of this metal, which would give rise to a dark colour similar to that occasioned by sugar. This source of fallacy has been lately pointed out by Dr. Rees, who recommends that no liquor potassæ should be employed but what has been kept in green glass vessels. The presence of lead in the liquor potassæ may be easily detected by means of the hydrosulphuret of ammonia.

M. Bouchardat prefers milk of lime to the solution of potash; first, because in the country it can be more readily obtained; and, secondly, because many of the extractive matters of the urine are darkened by potash, which is not the case with milk of lime.\*

viii. Digest some cheese, previously cleansed from foreign matter, in the suspected diabetic urine for a few hours, and then add to it some acetate of zinc; a white precipitate will be formed if sugar be present, owing to a portion of it being converted by the casein into lactic acid. (Ross.)

ix. "The urine is to be evaporated to dryness, the residue is then treated with alcohol, which dissolves the sugar, and all the extractiform matters soluble in this menstruum. By slowly evaporating this solution, the sugar crystallizes in small grain-like crystals, similar to the sugar of grapes." (Bell's Essay on Diabetes).

x. Add diacetate of lead to the urine, filter, remove the lead by means of sulphuretted hydrogen; filter a second time and evaporate to a syrup; treat this with alcohol and allow the solution obtained to spontaneously evaporate. The saccharine matter will then be procured in the crystallized form.

xi. Mix together sulphuric acid and bile until the precipitated choleic acid is redissolved, then add to the mixture a few drops of the urine to be examined, when, if sugar be present, a violet colour will be immediately produced.

\* See a translated paper by the Author, in the Med. Times, for March 6, 1847.

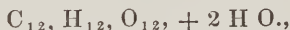
Should any albumen be contained in the secretion, it must be previously removed by ebullition. (Pettenkofer).

144. \*Some of these tests it will be seen only enable us to ascertain the presence of sugar in the urine, while the others admit of our calculating its quantity.

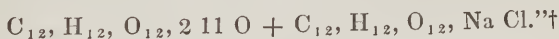
For the precise determination of the proportion of saccharine matter contained in a quart of urine, M. Bouchardat\* gives the preference to M. Biot's polarizing apparatus, and has proposed the following formula for this purpose. If the length of the tube in millemetres, in which the diabetic urine is examined, be represented by  $L$ , and the deviation measured with the naked eye, corresponding to the violet blue tint that is observed immediately preceding the appearance of the yellowish red—by  $a$ , then by multiplying 2353.6 by the latter, and dividing the product by the former, the quotient will be the amount of the sugar contained in a quart of this urine in grammes. Thus

$$\frac{2353 : 6 + a}{L}$$

Crystallized diabetic sugar contains two atoms of water, and is represented by the following formula :



"On saturating diabetic urine with common salt, and leaving it to spontaneous evaporation, crystals, three-fourths of an inch in diameter, may be obtained. They are not very regular in their form, but most of them are six-sided double pyramids. These crystals are hard, easily pulverizable, transparent, of a combined saltish and saccharine taste, and dissolve in about 3-7 parts of cold water and slightly in alcohol. The formula for this combination is :



145. To obtain the *Extractive Matters* evaporate a given quantity of urine to dryness over a water bath, treat the

\* Med. Times, March, 1847.

† Day in Simon's Chemistry, vol. i. p. 66.



residue with alcohol of 0.83 and the water extract will be precipitated in combination with the phosphates and sulphates. Collect the deposit on a weighed filter, wash it with alcohol of the same degree of strength and dry it, and its amount will be represented by the increase in the known weight of the filter. The proportion of *water-extract* contained in it can then be ascertained by the loss it sustains by incineration.

Mix the spirituous solution with the washings of the contents of the filter, evaporate the mixture to the consistence of an extract, and treat this when cold, with anhydrous alcohol. The *spirit-extract* together with the chlorides of sodium and potassium and a portion of the alkaline lactates will then be thrown down. When the supernatant *alcoholic* liquid is no longer rendered turbid by any further addition of anhydrous alcohol, it must be poured off from the residue, and this washed with pure alcohol; afterwards carefully dried on the water bath and weighed, and the *spirit-extract* estimated by the loss occasioned by incineration.

To determine the *alcohol-extract* and the ammonia salts, Simon proceeds in the following manner: the alcoholic fluid obtained from the precipitation of the spirit-extract, is evaporated on the water bath to the consistence of a thick syrup, then thoroughly dried over a strong sulphuric acid in a receiver and weighed. The residue is dissolved in a little water, and free baryta gradually added, a gentle warmth being kept up as long as it continues to dissolve, and as long as ammonia is perceptibly evolved. This point being attained the mixture is evaporated to the consistence of an extract, and moistened with a little alcohol of 0.83; a large quantity of anhydrous alcohol is then added, and the whole allowed to clear itself. There remain undissolved, chloride of barium, a compound of baryta, which has probably been added in excess. Dissolved in the alcohol are urea, lactate of baryta and a small quantity of free baryta. The undissolved portion is burnt in a platinum crucible, the residue incinerated, and the ash digested in water. The solution is then filtered, slightly acidulated with nitric acid, and the chlorine precipitated by nitrate of silver, when the chloride of ammonium can be calculated from it.

The alcoholic solution must be evaporated, the residue

dissolved in water, the solution filtered, and a current of carbonic acid passed through it, until the free baryta is precipitated: it must then be again filtered, acidulated with nitric acid and the baryta of the lactate of baryta precipitated by sulphuric acid. The lactate of baryta is estimated from the residual sulphate.

By subtracting from the solid residue of the alcohol extract the weight of the urea, of the free lactic acid, of the lactate of ammonia, and chloride of ammonium, we obtain the quantity of the alcohol-extract.

146. To detect an excess of the extractive matters boil a little of the suspected urine in a test tube, with a small portion of hydrochloric acid, when if the quantity be increased, the fluid will assume a dark hue, and will deposit a sediment of a brownish, or blackish, or even of an indigo blue tint, readily soluble in alcohol, to which it imparts a peculiar colour.

147. According to Heller "the existence of a large quantity of uroxanthin (6) in urine is indicated:

i. By the clear, light yellow colour of the urine when that secretion is acid, as in cholera, and sometimes in Bright's disease.

ii. By the presence of the products of its oxidation, uroglauclin and urrhodin, which, either of themselves, form a violet coloured sediment, or communicate that tint to a sediment already formed.

On allowing urine abounding in uroxanthin to stand for some time, it is observed that after the formation of the sediment has ceased, the fluid from the surface downwards, assumes a violet tint, and this change of colour takes place with a rapidity proportional to the amount of carbonate of ammonia produced by the decomposition of urea.

Hence, on keeping such urine in a high cylindrical glass, three distinct strata are observed; lowermost, a violet sediment; in the middle, yellow and nearly clear urine; and superiorly, a violet or purple turbid layer.

On shaking the glass, the whole urine assumes a blueish-green tint, because the urrhodin, formed principally at the surface, becomes converted, by agitation, with a full supply of atmospheric air, into uroglauclin, which, mixing with the central yellow layer of urine, developes a green

tint. The uroglaucon thus formed, ultimately settles as a blue powder on the sides, and at the bottom of the vessel. Hence there is obviously no fixed proportion between the quantities of uroglaucon and urrhodin.

III. If much uroxanthin is present, the crystals of uric acid (separated spontaneously, or by the addition of an acid) have a beautiful blue or amethyst tint.

IV. Lastly, if much uroxanthin is present, it may be recognized by the addition of concentrated nitric acid, (ten drops to half an ounce of urine,) which at once communicates a brilliant violet colour to the fluid: if a smaller amount is present, the change of colour is developed more slowly.

The nitric acid oxydizes the uroxanthin, and converts it into uroglaucon and urrhodin. Sulphuric and hydrochloric acids act similarly, but with less activity. If albumen is present in urine treated in this manner, it is either precipitated blue at once, or assumes that tint gradually, according to the amount of uroxanthin. This is constantly noticed in Bright's disease on treating urine abounding in uroxanthin with an acid, and allowing it to stand for a couple of days; uroglaucon separates in dark blue crystalline groups, visible to the naked eye, partly on the surface and partly at the bottom of the vessel. On taking a drop from the surface, and examining it under the microscope, uroglaucon [has the appearance of a dark central spot, from which proceed numerous lengthly tentaculæ].

To separate the two products of oxidation of uroxanthin, we collect on a filter the sediment thrown down by nitric acid, and agitate it with cold spirit of .830, which takes up the urrhodin, (as also does ether;) the residue is boiled for some time with spirit of the same strength, until the fluid becomes somewhat concentrated; we thus get a bright blue solution of uroglaucon.

To exhibit these substances in normal urine, the fluid must be so far evaporated as just to remain liquid. On adding concentrated nitric acid to the cold residue, a crystalline magma of nitrate of urea is at once formed; on adding to this a few more drops of nitric acid (and sometimes even this is unnecessary) it assumes a violet tint. If the crystalline mass is allowed to stand for some time, and is

then dissolved in the smallest possible quantity of distilled water, after being left at rest for some time, it deposits a sediment in which urrhodin and uroglaucin may be detected either by the microscope or by extraction with cold, and then with boiling spirit.

The action of nitrate of silver on uroxanthin is very singular. On precipitating the chlorine by an excess of nitrate of silver from urine acidulated with nitric acid, and then carefully neutralizing the filtered liquid by ammonia, there is not only a pale yellow precipitate of phosphate of silver, but the fluid assumes a brown tint, and in a short time there is likewise a brown sediment.

Heller has not yet succeeded in isolating uroxanthin. Uroglaucin associated with urrhodin, occurs in urinary sediments in Bright's disease, and in cases in which urine, abundant in uroxanthin, has become alkaline in the bladder. Heller has noticed it in these sediments forming groups of delicate prisms. It likewise assumes this form when urine abounding in uroxanthin is treated with nitric, sulphuric, or hydrochloric acid. In this case it is principally found on the surface of the fluid.

When allowed to crystallize from its cold spirituous solution, it forms groups which appear nearly black, but are blue and transparent at the edges.

Urrhodin appears to be a less oxydized product of uroxanthin than uroglaucin, and usually occurs in much larger quantity. It is most commonly observed in cases in which the urine is alkaline before emission, in consequence of containing much vesical mucus, and its developement in such cases is hastened by the addition of nitric acid. The method of isolating it has been already described. Heller has never succeeded in obtaining it from its spirituous solution in a crystalline form. It occurs in granules, which, under the microscope, appear of a beautiful rose-colour. It is resinous in its nature, and burns with a clear flame.

On treating uric acid crystals obtained from healthy urine, with cold alcohol, the pigment formed a carmine solution, and the uric acid remained comparatively devoid of colour, being of a yellowish brown tint, from the brown pigment of the urine. The spirituous carmine solution, on exposure to the air, gradually became purple, and had all the proper-

ties of uroglauclin, previous to which it appeared to be identical with urrhodin.

On treating the red sediment common in inflammatory affections, and tinged with uroerythrin, with hot and cold alcohol and ether, the red pigment remained unaffected, unless a little acid was added. The difference of insolubility in the above menstrua is therefore sufficient to separate uroerythrin from urrhodin.”\*

## II. INORGANIC ELEMENTS.

### (a.) *Normal.*

148. The normal inorganic elements of the urine are constituted by the fixed salts, namely the sulphates and phosphates of potash, soda, lime, and magnesia, the chlorides of their metals, and by silex.

To ascertain their amount evaporate three or four ounces of urine acidulated with nitric acid, incinerate the residue and weigh the melted white ash that is obtained. Dissolve a given portion of it in water, to which a small portion of nitric acid has been added. Filter the solution and the silicic acid, if any be present, will remain on the filter probably in combination with a little carbon. Wash it, burn it with the filter, and determine its weight. Then mix the solution with the washings of the contents of the filter and add liquor ammonæ to a slight excess. Warm the mixture and the earthy phosphates will be completely precipitated. Wash and dry them and expose them to a red heat and weigh them. To discover the proportion of lime dissolve them in very dilute nitric acid, and saturate the free acid with ammonia, then by adding oxalate of ammonia, the lime will be thrown down in the form of an oxalate. Separate it by filtration and calculate the amount of lime from its composition. Then add liquor ammoniæ to the clear fluid to precipitate the ammoniaco-magnesian phosphate. Collect the triple salt on a filter, wash it with water, dry and weigh it, and add the washings to the ammoniacal solution from which the earthy phosphates have been obtained, and supersaturate the whole with nitric acid. Then add chlo-

\* Simon's Chemistry by Dr. Day.

ride of barium until a precipitate is no longer formed, warm the fluid to promote the separation of the sulphate of baryta; separate this by filtration, wash it, expose it to a strong heat and weigh it. The quantity of sulphuric acid must then be calculated.\* Mix the washings of the sulphate with the solution from which it was procured, in a stoppered bottle a little larger than sufficient to contain the whole of the mixture, and add liquor ammoniæ to supersaturation, and afterwards chloride of barium as long as phosphate of baryta continues to be thrown down. Set the bottle by with the stopper in it for the salt to subside; then pour off the supernatant liquor; collect the precipitate, treat it as the sulphate and calculate the amount of acid it contains.† Mix the ammoniacal fluid now remaining, and which contains the fixed alkalies, with the washings of the phosphate, evaporate it, treat the residue with sulphuric acid, and, after the excess of acid has been expelled by heat, dissolve it in water. Filter the solution and separate the sulphuric acid by means of chloride of barium; again filter, and the chlorides of potassium and sodium will be obtained by evaporation. The proportion of chlorine may be determined by dissolving a given weight of the fixed salts in water acidulated with nitric acid, and then adding nitrate of silver, so long as a precipitate is formed, to the filtered solution.‡

149. *Soda* may also be detected in the urine by evapo-

\* Composition of Sulphate of Baryta :

Baryta	.	.	.	.	.	.	65.63
Acid	.	.	.	.	.	.	34.37
							<hr/> 100.00 <hr/>

† Phosphate of Baryta :

Baryta	.	.	.	.	.	.	68.20
Acid	.	.	.	.	.	.	31.80
							<hr/> 100.00 <hr/>

‡ Chloride of silver :

Silver	.	.	.	.	.	.	75.33
Chlorine	.	.	.	.	.	.	24.67
							<hr/> 100.00 <hr/>



rating the alcoholic solution, obtained by treating the secretion, reduced to the consistence of syrup, with this fluid; the chloride of sodium will then be left and may be distinguished under the microscope by its crystals, which, owing to their containing urea, have lost their natural cuboid shape and assumed that of octahedrons. By submitting the salt thus procured to the action of the blow-pipe a yellow flame will be produced.

The presence of soda in the urine is also indicated by the formation of the microcosmic double salt of phosphate of soda and ammonia, characterized by its rectangular prismatic crystals when the urine becomes decomposed.

150. *Potash*.—To detect this alkali dissolve the fixed salts in a little hydrochloric acid, extract them by alcohol, and add to the alcoholic solution of chloride of potassium some chloride of platinum which will throw down a yellow precipitate of chloride of potassium and platinum in the form of small yellow shining prismatic crystals. Potash also communicates a violet tint to the flame of a blow-pipe, and is precipitated from its aqueous solution by an excess of tartaric acid.

151. *Ammonia*.—Heintz demonstrates the presence of ammonia, and indeed of potash likewise, by the following process. He treats urine that has been recently passed with chloride of platinum and then adds to it a mixture of alcohol and ether, made in the proportion of three volumes of the former to one of the latter. A precipitate is thus formed which is collected on a filter, washed with etherized alcohol, dried and heated to redness. The residue is then repeatedly taken up with boiling dilute hydrochloric acid, the solution filtered and the filter afterwards burnt. The platinum which remains corresponds to the amount of ammonia and potash in the urine. By this process Heintz found the proportions of these alkalies to vary between 2.16 and 2.19, and 1.315 and 1.325 respectively in 1000 parts.

(b.) *Abnormal*.

152. The subcarbonates of lime and magnesia may exist in the urine, either in solution, being retained in it in that state by an excess of carbonic acid, or as a deposit. If in

solution, they will be thrown down when the acid is expelled by heat, and may be detected by their solubility in an acid with effervescence.

The presence of lime may be ascertained by the addition of oxalate of ammonia to the ammoniacal solution of the precipitate producing a deposit of oxalate of lime; while the existence of magnesia may be discovered by saturating the double carbonated salt with phosphoric acid, then setting the liquid by to crystallize, dissolving the crystals that are formed in hydrochloric acid, separating the lime in the manner just described, and adding to the supernatant liquor, solution of ammonia, when the ammoniaco-magnesian phosphates will be precipitated.

153. *Neutral Phosphate of Lime*.—To separate this salt from the ammoniaco-magnesian phosphate with which it is generally mixed, treat the deposit with acetic acid; this will dissolve the triple salt and leave the phosphate of lime behind in an amorphous state. It is precipitated from its solution in hydrochloric acid by liquor ammoniæ, and its acid solution, when neutralized with this alkali yields a precipitate on the addition of oxalate of ammonia.

The lime may be also separated, either from the solution of the phosphate in hydrochloric acid, or from the compound deposit, by means of sulphuric acid as an insoluble sulphate.

The phosphate of lime is precipitated from healthy urine in combination with the ammoniaco-magnesian phosphate by caustic ammonia, and with the phosphate of magnesia by liquor potassæ.

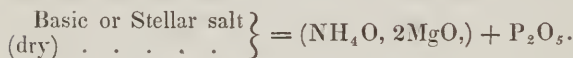
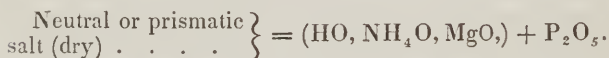
When examined under the microscope it generally appears as an amorphous powder, but is occasionally met with in the crystallized state, as for instance, when the urine has remained long in a state of decomposition.

154. The *neutral and bibasic ammoniacal-magnesian phosphates* are distinguished by the following characters. They are very slightly soluble in either hot or cold water, but are soluble in acids, from which they are again precipitated by ammonia. Mixed with caustic potash and heated, ammonia is evolved; and their solution in hydrochloric acid yields on evaporation crystals of hydrochlorate of ammonia.

155. The *neutral* triple phosphate is the form most commonly met with. It occurs during the commencement of the decomposition of the urine, or when a small quantity of ammonia is added to the healthy secretion, and may be recognized by its prismatic crystalline appearance under the microscope. It is the only variety of the triple salt that can occur in acid urine.

156. The *bibasic* form is met with in urine that has been long kept and become putrescent, and may be thrown down artificially from the healthy fluid by an excess of ammonia. It crystallizes in beautiful stellæ.

Dr. Bird gives the following formula as representing the probable composition of the two salts.




---

### *Inorganic Colouring Matters.*

157. *Cyanourine* when present in the urine communicates to it a fine blue colour and becomes deposited from it by repose. By collecting it on a filter it may be separated from any adherent matters by repeatedly washing it in water, in which it is insoluble, and then dissolving it in sulphuric acid, from which it can be thrown down by the gradual addition of magnesia. The cyanourine thus obtained has a dark blue colour, is without taste or smell, and is insoluble in cold, and but very sparingly so in boiling water. It is soluble in diluted acids which become of a brown or red colour in proportion to their quantity. On evaporating its sulphuric acid solution, a carmine extract is left soluble in water with the production of a brown coloured fluid. It is soluble in the hot solutions of the alkalis and their carbonates, the former assuming a brown and the latter a red hue.

158. *Indigo*. As we have already seen, this substance has been discovered in the urine of persons to whom it has been administered as a remedy, and has also been met with in cases where it appears to have originated in the system; an opinion which is greatly favoured by its composition namely,  $C_{16}, NH_5, O_2$ , being very similar to that of certain organic matters. Like cyanourine, it communicates a deep blue colour to the urine, from which it separates in the form of a blue powder. On collecting it by filtration it is found to be both tasteless and inodorous, insoluble in water, soluble in ether and alcohol, to which it gives a yellow colour, and also in sulphuric acid, the solution being purple. It is converted by nitric acid into the nitro-picric; and is deoxidized by sulphuretted hydrogen, various sulphites, and the protoxide of iron, &c., with the addition of an alkali, and is thrown down from the alkaline solution, when this is saturated by hydrochloric acid, in a white flocculent crystallized state, to which the blue colour becomes restored on exposure to the atmosphere.

159. To detect the presence of indigo in a deposit, place the latter in diluted alcohol, with a little grape sugar and caustic potash, and the blue colour, if due to indigo, will be replaced by a yellowish red, which on shaking the mixture, becomes converted, first into a deep blood red and then into a green; the yellowish red being at length eventually restored when the fluid is left at rest.

160. *Prussian Blue* has been discovered in the urine by various observers, and M. Julia Fontanelle detected it in the secretion of a boy who had swallowed ink. It forms a blue deposit characterized by its insolubility in water and alcohol, and by its being decomposed by a solution of potash with the production of peroxide of iron which is precipitated, and a yellow liquid of ferrocyanide of potassium, from which this salt may be obtained in crystals on evaporation.



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\* \* \* The figures refer to the paragraphs not to the pages.

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


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